THE SCIENCE REPORTS OF THE RESEARCH INSTITUTES
TÔHOKU UNIVERSITY SERIES D (Agriculture)

THE REPORTS OF THE INSTITUTE OF AGRICULTURAL RESEARCH

TÔHOKU UNIVERSITY

Vol. 3
1951

Published by
Tôhoku University, Sendai, Japan
(Rep. Inst. Agr. Res. Tôhoku Univ.)

Studies on the Mechanisms of Phosphorus and Iron Absorption by Rice Plant. II*

Hideo OKAJIMA and Jiro KIMURA

(Received May 1, 1951)

I. Introduction

In the former report,[1] the authors have studied on the absorption of phosphorus and iron by the rice plant, in comparison with that of the barley plant, for explaining the speciality of the rice plant absorbing nutrition. From the results of the microchemical tests and of the fractional analysis on the phosphorus form, the possibility of combination of phosphorus and iron in the plant bodies was deduced. Namely, inorganic phosphorus increased by the increasing supply of phosphorus and iron and a fraction which was thought to contain iron phosphate increased with increasing supply of iron. The physiological effect by the combination of phosphorus and iron may be different in the rice and the barley. In the rice plant, excess of phosphorus would make iron inactive causing the injurious effect by poor active iron, while in the barley plant, iron acts to phosphorus causing the deficiency of phosphorus. This was deduced from the phenomena that the rice in water culture was injured by high phosphorus application, which was, however, recovered by supplying a large amount of iron, on the other hand, the barley grew well in a solution containing a large amount of phosphorus which was, however, injured by supplying a large amount of iron.

In the former report, the relation between phosphorus and iron was investigated chiefly by the experiments on phosphorus form in plant body, but the iron form was not studied experimentally, in the present report, the study was conducted by the experiments on the iron form. The effects of the change of supplying phosphorus and iron to the following items were examined: (1) active iron, (2) iron by microchemical tests, and (3) the activities of catalase and peroxydase.

The study was done by the help of the research fund of the Educational Department, for which the authors express their thanks.

---

* The 59th report of the Institute for Agricultural Research, Tohoku University (1951).

II. Experiments of active iron.

On investigating the action of iron, J. Oserkowsky[2] stated that the phenomena of chlorosis caused by the deficiency of iron and the relations between other physiological actions and iron would not be explained by mere analysis of iron in the plant body, which was also approved by the authors' experiments in 1949.

It is a question how to detect the active iron. J. Oserkowsky extracted iron with many solvents for finding out the mutual relation between the content of chlorophyll and iron in pear leaves. And he found that only the iron extracted with n-HCl had a relation with the content of chlorophyll. The iron thus extracted was called as active iron. W. T. McGeorge[3] pointed that the ratio between the active iron of Oserkowsky and the total iron had a meaning.

Adopting the above two opinions, the authors determined the active iron by the method of Oserkowsky and calculated the ratios of active iron to total iron.

1. Seedlings.

Rice : "Norin 16" variety of rice was sterilized as usual with 0.1% solution of usprun for 6 hours on the 29 th of May and were sown on the 3rd of June on the net which was paraffined and floated in the ordinary distilled water. On the 20th of June, 4 uniformly grown seedlings of 12 cm height were transplanted to each culture jar.

Barley : "Aizu 2" were sterilized according to ordinary method and sown on the 24th of September in the sand bed which was washed with hydrochloric acid. On the 9th of October, 4 uniformly grown seedlings of 10 cm height were cultured in each jar.

2. Culture vessels.

The same vessel used in the former report was used.

Table 1. Composition of culture solutions. (mg in 1*l* of solutions)

P_2O_5	$(NH_4)SO_4$	$Ca(NO_3)_2$	KNO_3	$Mg(NO_3)_2$	$CaH_4(PO_4)_2$
p.p.m.					
20	96.5	185.7	73.8	189.5	34.2
150	96.5	30.0	73.8	189.5	256.4

Table 2. Examination plan.

	A	B	C	D	E	F
	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.
P_2O_5	20	20	20	150	150	150
Fe_2O_3	0	10	50	0	10	50

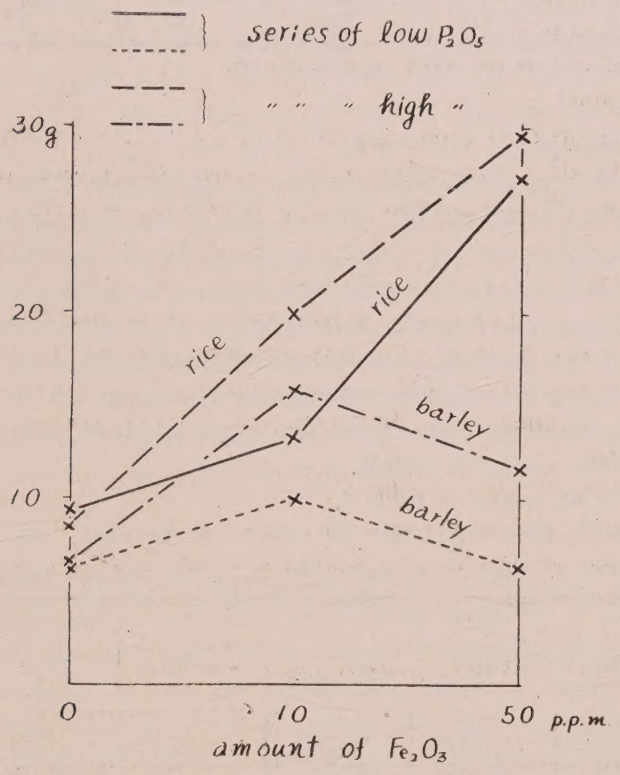
3. Culture solutions and examination plan.

The composition of culture solutions is shown in table 1, and 6 series were settled according to the difference of the amounts of phosphorus and iron.

As described in the former report, iron was used in the form of iron citrate.

4. Examination of plant growth and yield.

The growing state was on the same tendency with what obtained in the former experiments in 1949, described in the former report[1].



Fi. 1. Fresh weight of the rice plant and the barley plant.

The growth of the barley was however poor, comparing with that in 1949. As already shown in Table 3 and Figure 1, a better growth was made in the rice plant by the increase of iron supply. The barley grew well in B and E series containing 10 p.p.m. of Fe_2O_3, but not well in C and F series of iron rich series. Especially, in C series the rice grew well, but the barley was poor and showed the deficiency of phosphorus. The tendency was coincidental with the fact perceived in 1949, which showed a marked difference in absorption of phosphorus and iron in the rice and barley.

Table 3. Yield of the rice and the barley. (cultured for 1 month)

Series	Rice			Barley		
	Length of tops	Number of stems	Fresh weight	Length of tops	Number of stems	Fresh weight
	cm		g	cm		g
A	51	7	9.4	24	5	6.2
B	56	11	13.3	29	7	10.0
C	61	17	27.3	20	4	6.3
D	51	4	8.5	24	5	6.4
E	62	13	20.1	34	10	15.9
F	61	18	29.6	29	8	11.8

Note : The numbers are mean values of 8 pots.

5. Determination of active iron.

The analysis was conducted according to Oserkowsky's method. By using the above nutrient solutions, the rice and the barley were grown. After one month the tops of the plant were collected and quickly dried at 60°C and powdered in a mortar. About 4 g of the powder were shaken in a shaking bottle with 60 cc of n-HCl for 24 hours and filtered. Twenty five cc of the filtrate were centrifuged and the iron in the clarified solution was colorimetrically determined using a thiocyanate solution by ordinary method after separating off silicic acid, which was assumed to be active iron. Total iron was determined by ordinary method after calcining the powdered sample.

The results are shown in table 4.

Table 4. Contents of active iron in the rice and the barley.

Series	Rice			Barley		
	Active Fe	Total Fe	Active Fe / Total Fe	Active Fe	Total Fe	Active Fe / Total Fe
	mg/g	mg/g	%	mg/g	mg/g	%
A	0.137	0.171	80	0.230	0.404	57
B	0.341	0.418	81	0.177	0.410	43
C	0.390	0.423	92	0.630	1.052	59
D	0.151	0.204	74	0.251	0.518	48
E	0.302	0.402	75	0.140	0.268	52
F	0.188	0.234	80	0.139	0.569	24

The contents of active and total iron of the rice in iron supplying series (B, C, E, F) are larger than those in no iron series. But the increase of iron in F series (higher supply of iron) is very low. There is, therefore, no definite tendency in difference of change of active and total irons by the supplying amount of iron.

As McGeorge suggested, the ratio has an increasing tendency owing to the increase of iron supply, and the ratio in the series (A, B, C,) supplied with less

phosphorus is larger than that in the series of more supply of phosphorus (D, E, F). The active iron ratio increases according to the increase of iron supply. As the ratio of iron toward phosphorus becomes larger in less phosphorus supply series, the ratios of active iron become higher. This is in accordance with the result obtained from the phosphorus form in the former report. Namely, the result is coincidental with the hypothesis that, in the rice plant, as phosphorus makes iron inactive in the plant, chlorosis is caused when iron supply is small, which is however recovered by supplying a larger amount of iron.

In the case of the barley, there is no definite tendency about the ratio. But that the ratio in F series, in which a large amount of phosphorus and iron being given, is very small, such as 24, is an interesting fact from that the more iron is given the worse the growth of the barley. The content of total iron is fairly large even in no iron series. But as the amount of active iron is small, the ratio in the barley is about 50 though that in the rice is more than about 70. This fact is coincidental with the conception that the barley has a large absorption power for iron, making phosphorus inactive. This is also cleared up from the fact that total iron is 1.052 mg, a maximum value, in C series (phosphorus deficiency), supplied with a small amount of phosphorus and a large amount of iron.

These results show that, in the rice plant, by increasing iron supply, the ratio of active iron increases and prevents the injury caused by the excess of phosphorus. In the barley, the content of total iron is large, but the ratio of corresponding active iron is small. It is therefore deduced that phosphorus mainly acts in the rice, while iron in the barley.

III. Iron in the tissue by microchemical tests.

In the former report, an inorganic phosphorus in the tissue was investigated by microchemical tests, as a means to explain the existence of iron phosphate in the plant tissue. It was found that the amount of inorganic phosphorus increased as supplying amount of iron and phosphorus increased. From the result, the existence of iron phosphate in the plant body was deduced.

For clearing up the problem, the change of iron contained in the tissue was investigated by microchemical tests.

1. experimental method.

As the sample, leaves and stems of the rice and the barley cultivated for one month in the water culture were used as in the case of experiment on active iron. Ferrous and ferric irons in the tissue were observed according to the method of H. Molish[4].

Ferrous iron : A 2% ferricyanide solution was added to slices of the tissue, to which 5% HCl is added drop by drop. After 30 minutes, there are washed with distilled water and examined under a microscope. When blue color appeared,

ferrous iron was assumed to be present, which was called as an immediate iron. As some of iron in the tissue did not react with a 2% ferricyanide solution at once, they were immersed in the solution for 1 hour, then there were treated with 5% HCl. When blue color appeared, it was called as ferrous iron after 1 hour.

Ferric iron : In this case a 2% ferrocyanide solution was used instead of the ferricyanide solution. The rest treatment was same with the former case. The immediate value and the value after 1 hour were observed respectively as in the case of the ferrous iron.

2. Experimental results.

By the above method, tests were made using fresh leaves and leaf sheaths. The results are as follows :

A sereis (20 p.p.m. P_2O_5 ; 0 p.p.m. Fe_2O_3) : In rice leaves, both ferric and ferrous irons exist in very small amount ; ferric iron appeared as 2 or 3 small colored spots on the epidermis cell. Fecrrous iron appeared as very small colored spots on the vascular bundle. These color reactions had no change after 1 hour's reaction. In the stem, ferrous iron partly colored faintly spreading (mainly in parencyma and partly in vascular bundle) : after 1 hour spots of deep blue color appeared on the above color, the reaction of ferric iron colored wholely the parenchyma and dense blue spots were observed on the above color.

In leaves of the barley, ferric iron appeared in spots much in number than in the rice plant. The color reaction due to ferrous iron was not observed. In the stem, the whole was colored with light blue color, but there was no distinct difference between ferrous and ferric irons.

B series (20 p.p.m. P_2O_5 ; 10 p.p.m. Fe_2O_3) : In leaves of the rice plant, ferric iron colored near the vessel part with dense blue color and ferrous iron appeared in spots in the part of vascular bundle. In the stem, ferric iron lightly colored the whole, on which stripped deep blue color was observed after 1 hour, ferrous iron colored only vascular bundle part and there appeared no change after 1 hour. In leaves of the barley, ferric iron gave deep blue color reaction on the part of vascular bundle and ferrous iron appeared as spots on the same part. In stems, ferric iron gave color reaction uniformly throughout admixed with spots and ferrous iron appeared strongly mainly on the part of vascular bundle.

C series (20 p.p.m. P_2O_5 ; 50 p.p.m. Fe_2O_3) : In the case of the rice plant, ferric iron gave very faint color reaction almost same with A series. After 1 hour, the color appeared extensively on the epidermis cell and the vascular bundle. Ferrous iron was more than that in A series, but no change appeared after 1 hour. In light and deep color and ferrous iron was limited to the part of vascular bundle.

In leaves of the barley, ferric iron appeared largely immediately after the reaction ; the reaction after 1 hour was same and ferrous iron also largely appeared.

In stems, ferric iron appeared in deep blue color.

D series (150 p.p.m. P_2O_5 ; 0 p.p.m. Fe_2O_3) : In leaves of the rice plants, ferric iron slightly appeared in the epidermis cell and ferrous iron did not appeared, but slightly after 1 hour. In stems ferric iron widely appeared in the parenchyma cells. Ferrous iron appeared very slightly in the part of vascular bundle.

In leaves of the barley, ferric iron appeared as in the case of the rice plant and in larger numbers of spots. But ferrous iron did not appeared. In stems, ferrous and ferric irons reacted in lighter blue color than the rice plant.

E series (150 p.p.m. P_2O_5 ; 10 p.p.m. Fe_2O_3) : In leaves of the rice plants, the reaction of ferric iron appeared slightly at first, but largely after 1 hour. The reaction of ferrous iron was same. In stems, the reaction was almost same with B series of poor phosphorus.

Table 5. Amounts of iron in the tissues of the rice plants found by the microchemical tests.

Series	Atomic value of iron (valent)	Fresh leaves		Stems	
		Immediate reaction	Reaction after 1 hour	Immediate reaction	Reaction after 1 hour
A	3	0~+	0~+	+++	++++
	2	0~+	+	++	+
B	3	++	+++	++++	+++++
	2	++	++	++	++
C	3	0~+	++++	+++++	+++++++
	2	++	+	++	++
D	3	+	++	+++	++++
	2	0	0~+	0~+	0~+
E	3	0~+	+++	++++	+++
	2	+	0~+	+	+++
F	3	0~+	++++	+++++	++++
	2	+	+	++	+++

Table 6. Amounts of iron in the tissues of the barley plants found by the microchemical tests.

Series	Atomic value of iron (valent)	Fresh leaves		Stems	
		Immediate reaction	Reaction after 1 hour	Immediate reaction	Reaction after 1 hour
A	3	+	++	++	++
	2	0	0	++	++
B	3	++	++	++++	++++
	2	+	+	+++	+++
C	3	++++	++++	++++	++++
	2	++	++	++	++
D	3	+	+	++	+
	2	0	+	0~+	+
E	3	+	+	+++	++
	2	++	++	+	++
F	3	+++	+++	++	++
	2	+	+	+	+

In the barley, the first reaction was large in leaves, differing from the rice plant. In stems, the reaction was smaller than that in the rice.

F series (150 p.p.m. P_2O_5 ; 50 p.p.m. Fe_2O_3) : In leaves of the rice plant, the color reaction was in the same tendency with that of E series, but quantitatively larger. In stems, the color reaction was small in the barley rather than the rice.

Differing from the case about phosphorus form, it was difficult to express numerically the difference of each series from the result of the observation. But for comparison, the result may be expressed numerically in Tables 5 and 6, judging from the color tone, dimensions of the colored parts, and state of color spots.

In the rice plant, iron, mainly ferric one, increased in stems as the increase of iron supply. In stems the content of iron was small and the reaction did not appeared immediately, but the reaction after 1 hour showed the increase of iron content by the increase of iron supply. This result suggested the presence of firmly combined substance of phosphorus and iron.

In leaves of the barley plant, the increase of reaction due to ferric iron by the increase of the iron supply was same with the case in the rice plant. But immediately appeared in larger quantity, which supports the conception that iron mainly predominates in the plant as cleared from the result in C series rich in iron supply. In stems, when the concentration of phosphorus becomes higher, the reaction of iron is week. The reason was not clear whether the iron which gives microchemical tests, was due to comparatively weekly combined one or the iron moves to leaves.

The above stated results do not contradict to the conception obtained from the phosphorus form that phosphorus mainly acts in the rice plant, while iron in the barley plant as stated in the former report.

IV. Examination of activities of catalase and peroxydase.

By the progress of enzyme chemistry, the role of enzyme as a catalyst in chemical reaction is gradually explained. Among these, many enzymes containing iron as an active component, are found, and its role, especially its important position in respiration and other physiological actions, is cleared up. Recently Lundegårdh[5] suggested the action of the iron enzyme system in the explanation of nutrient absorption by the roots of plants, by which the iron enzyme system became important.

In the studies, it is the most difficult point to know the real nature of the so-called active iron. Considering that the enzyme activity of the iron-enzyme will express one part of active iron, the effect of change of the amounts of phosphorus and iron on the enzyme activity was traced as a means to complete

the study. The examination of enzyme activity was conducted on catalase and peroxydase, parts of the iron enzyme.

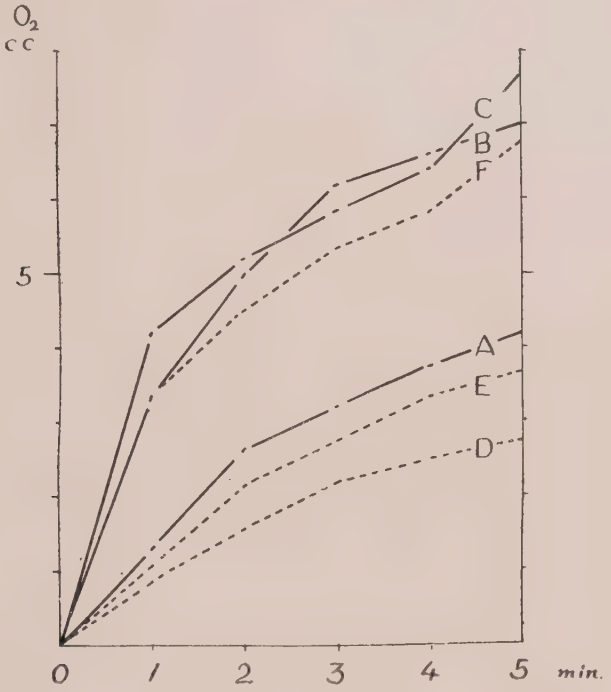


Fig. 2. Amount of oxygen evolved by catalase.

1. Experimental method.

As samples, the rice plant cultured in the same series used for the analysis of the active iron was used. The activity of catalase was determined by the method of Knott[7] and that of peroxydase by the method of Masamune and Kodama[6] as follows.

Catalase : Oxygen evolved by the action of ground tissue on hydrogen peroxide was volumetrically measured. 2 g of fresh plant material was ground with 10 cc of 0.10 M alcohol and quartz sand in a motar under cooling with ice, to which 200 cc of 0.005 M alcohol are added and shaken for 30 minutes and then centrifuged for 10 minutes and the filtrate is diluted. The extract is reacted with hydrogen peroxide under a definite temperature. Oxygen gas thus evolved was collected in an eudiometer and measured. The measured value was taken as an enzyme activity of the catalase.

Peroxydase : The enzyme activity was measured by utilizing the formation of red purpurogallin by the oxidation of pyrogallol by the enzyme under the

presence of hydrogen peroxide. 2 g of the sample was thoroughly ground with 20 cc of distilled water and quartz sand and the juice thus produced was diluted to a definite amount. One cc of this solution is mixed and reacted for 5 minites with 30 cc of 1% pyrogallol, 2 cc of acetate buffer and 1 cc of 6% H_2O_2, then the reaction was stopped with sulfuric acid and extracted with ether after 5 minutes. The amount of purpurogallin was determined by comparing the color of the etherial solution with the standard solution, the amount being taken as the enzyme activity of the peroxydase.

2. Experimental results.

Catalase: According to Figure 2, the amount of oxygen evolved by catalase for 5 minutes increases by the increase of the amount of iron in nutrient solution, notwithstanding the amounts of phosphorus, namely, the activity of catalase increases with the increase of iron in the solution. The tendency of the increase does not change according to the change of phosphorus in the nutrient solution, but the amount of evolved oxygen in less phosphorus series (A, B, C) is larger than that in larger phosphorus series (D, E, F). Namely, by increasing the amount of iron to less phosphorus series, the activity of enzyme becomes stronger. The result is coincidental with the authors' conception that the excess of phosphrus, in the rice plant, causes chlorosis by making active iron to inactive, which is recovered by increasing the amount of iron.

Peroxidase: In Table 7, "immediate" shows the result obtained by measuring the sample immediately after the grinding of the sample and "after 10 minutes" the result by measuring after 10 minutes after the grinding. The result shows the same tendency with the case of catalase, but there is no definite difference by the concentration of phosphorus in the nutrient solution.

Table 7. Amounts of purpurogallin produced by 1 g of the sample (mg)

Seris	Immediate	After 10 minutes
A	69.8	39.9
B	64.8	52.5
C	79.5	87.2
D	48.8	43.0
E	53.3	54.9
F	64.4	53.6

It is perceived that the enzyme activity is increased by the increse of iron in the solution.

From the above results, it is difficult to determine the mutual action of phosphorus and iron in the plant tissue, but the relation between the enzyme activity and the amount of phosphorus and iron in the nutrient solution will give a support to the conception that excess of phosphorus makes active iron to inactive one in the rice plant.

V. Summary

In previous paper, the authors have investigated physiological functions of phosphorus and iron in rice, in comparison with those in barley, chiefly by the experiments on phosphorus forms in plant body.

In the present paper, by the experiments on iron forms in plant body, further evidence is given in support of the suggestion that phosphorus and iron may be combined in some extents, thus making iron in rice and phosphorus in barley unavailable for their metabolism.

The seedlings of rice and barley which had been grown in the culture solutions with various amounts of phosphorus and iron, respectively, were used for the analysis of active iron, detections of iron by microchemical tests and determinations of the activities of catalase and peroxydase.

1) Active iron : In rice, the ratios of active iron to total iron increase with the supply of iron and their values are high when the supply of phosphorus is low. In barley, the content of total iron is large but the ratios are lower than in rice.

2) Microchemical tests for iron : In both the plants, ferric irons increase with the supply of iron, but in rice their reactions are slower than in barley.

3) Catalase and peroxydase : In rice, these functions increase with the supply of iron and these tendencies are high in the case of low phosphorus applications.

These results support the suggestion mentioned above.

Literature cited

(1) J. Kimura and H. Okajima, Sci. Rep. RITU. D (Rep. Inst. Agr. Res. Tôhoku Univ.) **1-2** (1951), 1.
(2) J. Oserkowsky, Plant Physiol. **8** (1933), 449.
(3) W. T. McGeorge, Soil Sci. **68** (1949), 381.
(4) H. Molisch, Microchemie der Pflanze 3 Aufl Jena, 1923.
(5) H. Lundegårdh, Arkiv för botanik **32** A (1946), 1.
(6) H. Masamune and K. Kodama, Jour. Biochem. **14** (1932), 475.
(7) J. E. Knott, Cited by Eyster, H. C., Plant Physiol. **25** (1950), 631.

Investigation on "Viviparous" Germination of Seed in Barley Varieties in Japan*

Kengo YAMAMOTO

(Received May 10, 1950)

In the north-eastern section of Japan, we usually have continued rainfall and cloudy weather day after day in June and a part of July, a meteorological phenomenon characteristic of the wet season, as they call it. As this spell of rain falls on the time to harvest and dry barley and wheat, these crops suffer more or less damages by rain, and the viviparous germinationoccurs in them, inflicting, in the worst case, a heavy loss upon the crop both in quality and yield. This, as one of the damages on agricultural crops, presents a grave problem in the northeastern part of Japan.

The author will report in the following the results of a series of investigations into this problem carried out with the Japanese varieties of barley.

I. Test of viviparous germination capacity of seed in barley varities

In spite of great importance of the test of the viviparous germination capacity in barley from the point of view, among others, of development of superior varieties of this crop, only relatively little attention has been paid to this phenomenon up to the present. In this view, the author tested the viviparous germination capacity of 190 principal varieties of barley from different parts of Japan.

(1) Varieties used and method of test.

190 varieties were selected from among the 216 under cultivation at Furukawa Branch Station of Miyagi Prefectural Agricultural Experiment Station.

The ears of the plants used, which had turned yellow apparently to an approximately same degree, were cut with scissors, and some of them were used for test purpose on the same day, while others were kept hanging indoors for a certain period. The wooden box of germination test was modelled after that of M. Inazuka (1938). A glass plate was covered with a filter paper, on which seeds were placed, not stripped in Plot A and stripped in Plot B. The temperature was maintained at the usual indoor temperature, and the moisture was supplied

* The 41st report of the Institute for Agricultural Research, Tohoku University (1950).

Table I. Varieties used for materials.

No.	Name	Source
1	Sangatsu	Yamagata
2	Kinaizatsu no. 25	Miyagi
3	Santoku	Chiba
4	Shiromugi	Toyama
5	Aizu no. 4	Fukushima
6	Aizu no. 6	,,
7	Kaikei no. 38	,,
8	Kaikei no. 39	,,
9	Bozumugi no. 1	,,
10	Suifu	Ibaraki
11	Bozu no. 1	Chiba
12	Sakigake	Aichi
13	Yokozuna	,,
14	Omugishin no. 1	Niigata
15	Kedakarokkaku	Ishikawa
16	Shinomugi	,,
17	Hakkoku	Fukui
18	Suishosekitori no. 305	Yamanashi
19	Dairokkaku no. 22	,,
20	Toranoo no. 7	,,
21	Hanbozu no. 25	,,
22	Dairokkaku	Nagano
23	Shigahakkoku no. 5	Shiga
24	Wase Golden melon	Kyoto
25	Kinaikono	Osaka
26	Baitori no. 11	Hiroshima
27	Ichiwase	Aichi
28	Hosokara no. 2.	Aomori
29	Miyagi no. 123	Miyagi
30	Kaikei no. 41	Fukushima
31	Sekitori	Toyama
32	Shigahozoroi no. 1	Shiga
33	Bozuomugi no. 1	Kyoto
34	Hayakiso no. 3	Shimane
35	Koya	Saga
36	Shirochinko	Kanagawa
37	Shirochinko	Gifu
38	Kobinkatagi	Shimane
39	Ehimehadaka	Ehime
40	Nikaku Chevallier	Hokkaido
41	Sapporo-rokkaku	,,
42	Miyagi no. 13	Miyagi
43	Miyagirokkaku no. 23	,,
44	Aizu no. 2	Fukushima
45	Kaikei no. 37	,,
46	Kaikei no. 42	,,
47	Kaikei no. 47	,,
48	Sekitori no. 3	,,
49	Hosomugi no. 3	,,
50	Shiromugi no. 6	Gunma
51	Shiroyoshikara	,,
52	Tanikaze no. 105	Gifu
53	Rokkaku no. 1	Niigata
54	Rokkaku Chevallier	,,
55	Taishomugi	Toyama
56	Fukuishiromugi	Fukui
57	Raiden	Nagano
58	Shiroomugi	Hyogo
59	Benkei no. 3	Yamaguchi
60	Hakata no. 2	,,
61	Aizuhadaka no. 3	Fukushima
62	Shirohadaka no. 1	,,
63	Taihaku	Mie
64	Shirodo no. 6	,,
65	Shigawasehadaka no. 6	,,
66	Chinko no. 83	Tokushima
67	Shirochinko no. 1	Kagawa
68	Ehimehadaka no. 2	Ehime
69	Kagoshimakobai no. 1	Kagoshima
70	Sanjakuhonaga	Miyagi
71	Nanbuhonaga	,,
72	Bizenshiroishi	,,
73	Hosokawanishiki	,,
74	Omugi no. 4	Akita
75	Hanbozu	Yamagata
76	Iwateomugi no. 1	Iwate
77	Kaikei no. 30	Fukushima
78	Kaikei no. 45	,,
79	Bizenwasesaki no. 1	Saitama
80	Hozoroeibaraki no. 1	Ibaragi
81	Sekitorita no. 2	Gunma
82	Hozoroi	Chiba
83	Kingyoku	Tokyo
84	Wasemino	Kanagawa
85	Kamakura	,,
86	Kuromugi no. 148	Shizuoka
87	Shirokuma	Aichi
88	Baitori no. 10	Mie
89	Miechinko	,,
90	Nagaoka	Niigata
91	Baitori no. 1	Kyoto
92	Shiroomugi no. 1	,,
93	Hayakiso no. 2	Shimane
94	Golden melon	Nagasaki
95	Bozu	Aichi
96	Marumi no. 16	Hokkaido
97	Shiraume	Aichi
98	Kobinkatagi no. 36	Mie
99	Shirochinko no. 2	,,
100	Kosaba no. 2	Tottori
101	Ichinenmugi no. 2	Shimane
102	Nagasakihadaka	Yamaguchi
103	Kagawa no. 5	Tokushima
104	Kagawahadaka no. 1	Kagawa
105	Kobin no. 1	,,
106	Kairyobozu	Ehime
107	Eijohadaka	Saga
108	Oitahiza no. 85	Oita
109	Kairyohadaka	,,
110	Oitaminori no. 10	,,
111	Oitahadaka	,,
112	Sasaotsubu no. 2	Miyazaki
113	Kosaba no. 1	,,
114	Nejire no. 2	,,
115	Kagoshimakamaori no. 1	Kagoshima
116	Kairyohiza no. 1	,,
117	Hosomugi	Yamagata
118	Miyagi no. 12	Miyagi
119	Tosan no. 1	,,
120	Baitori no. 18	,,
121	Koshimaki no. 23	,,
122	Tanikaze	,,
123	Mi no. 23	,,
124	Miyako	,,

No.	Name	Source
125	Yukishirazu	Miyagi
126	Bizenwase no. 53	Fukushima
128	Toranoosaki no. 1	Saitama
129	Goseyonkokusaki no. 1	,,
130	Takebayashi-ibaraki no. 2	Ibaraki
133	Shikoku	Tokyo
134	Iwata no. 3	Shizuoka
135	Shiroomugi no. 79	Gifu
136	Hida	Niigata
137	Ishikawachinko	Ishikawa
138	Dairokkaku no. 1	Kyoto
139	Wasebozu	Okayama
140	Hanbo no. 2	Shimane
141	Daikoku	Nagasaki
142	Suigenomugi no. 14	Korea
143	Suigenomugi no. 18	,,
144	Neihen-zairai	,,
145	Sangatsu ko no. 1	Hokkaido
146	Josyushirohadaka	Ibaraki
147	Kobinkatagi no. 1	Aichi
149	Hadakarikuu no. 1	Niigata
150	Kokubi no. 1	Kyoto
151	Kinainitahadaka	Osaka
152	Osakayakko no. 52	,,
153	Osakashirochinko no. 12	,,
154	Kinai Kyoshinkai no. 2	,,
155	Shinshinriki no. 1	Hyogo
156	Akashinriki	,,
160	Kodama no. 13	Wakayama
161	Tankankodama	,,
162	Kochinko no. 4	Yamaguchi
163	Hyogohadaka	,,
164	Shiromugi no. 8	,,
166	Kochiwasehadaka	Kochi
167	Sagahadaka	Saga
171	Mishimahadaka	Nagasaki
172	Wasehadaka	Kumamoto
174	No. 2 Kumashima	,,
177	Zairaihadakamugi	Miyagi
178	Binbosuke	,,
179	Mi no. 8	,,
180	Yoneyamamugi	,,
181	Aizu no. 1	Fukushima
182	Ososekitori	,,
183	Sekitorisaki no. 1	Saitama
184	Manriki	Gunma
185	Ashigarawase	Kanagawa
186	Shizuoka-shiro-rokkaku	Shizuoka
187	Rokkaku no. 2	Niigata
188	Yanehadaka no. 1	Kyoto
199	Hozoroi no. 11	Miyagi
200	Iwate mensh early	Iwate
201	Shidawake	Miyagi
202	Hozoroi	,,
203	Kinukawa	,,
204	Golden melon no. 1	Tochigi
205	Golden melon no. 1	Saitama
206	Tanikaze no. 2	Aichi
207	Kyushobo no. 49	Gifu
208	Kobaisaki no. 1	Saitama
209	Osaka no. 6	Mie
210	Yukinoshita	Miyagi
211	Date no. 2	,,
212	Miyagi no. 55	,,
213	Sanjakuhonaga	,,
215	Mukashitanikaze	,,

in a same certain amount for each of Plots A and B.

(2) Varietal difference in barley in viviparous germination capacity.

Germination varied with varieties. Some varieties showed 30% germination already on the day of ripening, while some others none at all. The more days elapsed after ripening, the higher became the percentage of germination generally. Difference in the number of days before germination was observed likewise among varieties. The earliest germination occured three to four days after being placed in bed, and a general tendency was observed that the longer it was after ripening, the more readily occurred germination.

On the basis of the data obtained, the 190 varieties could be classified into the the following fourteen classes according to the capacity of viviparous germination.

Figure 1 indicates a noticeable variation in the viviparous germination capacity among varieties. This variation, however, can not be adequately represented by that in the percentage of germination alone. By taking into account also the number of days which elapsed before germination occurred, this matter will be brought into light in relation to the actual damages by rain on the field.

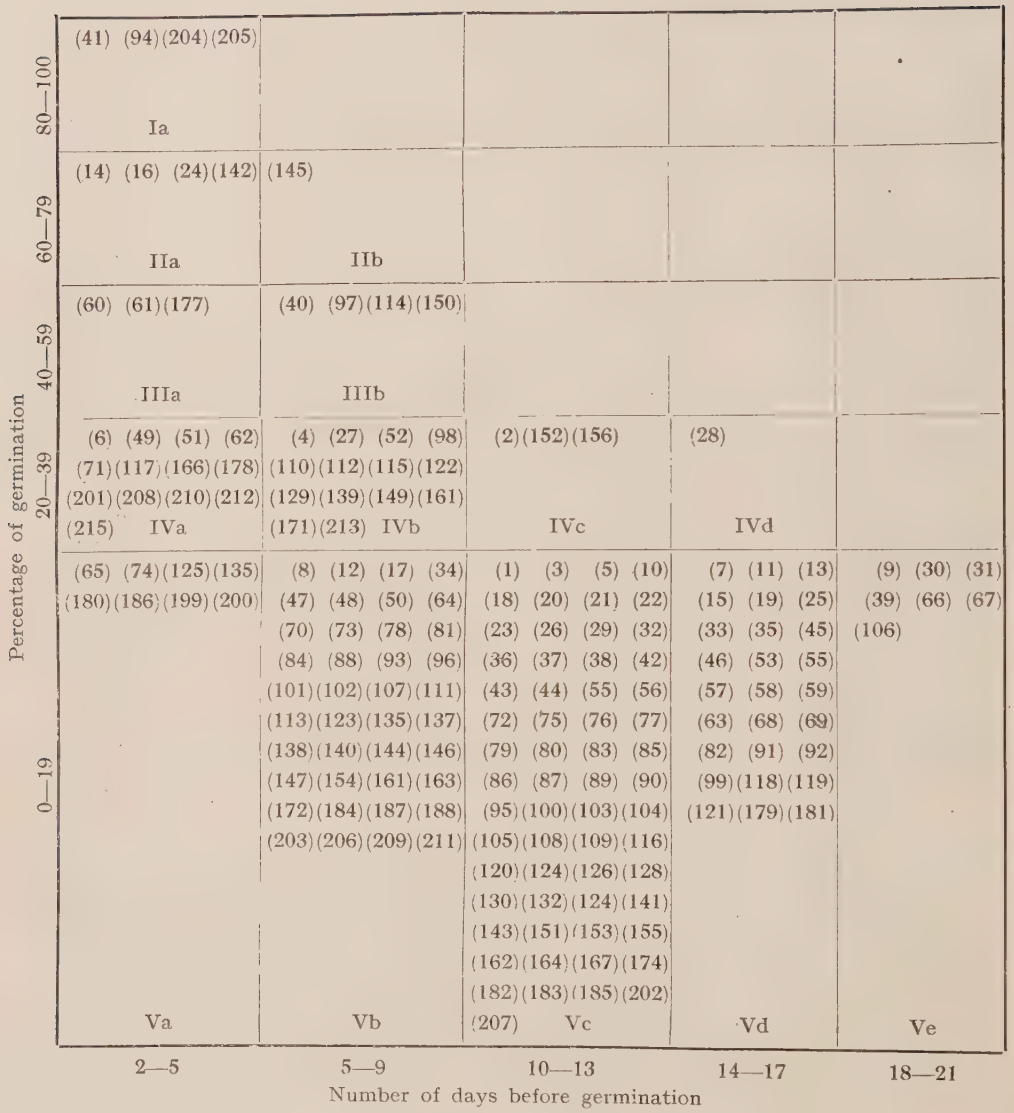


Fig. 1. Relation between the percentage of germination and the number of days before germination in barley varieties.

For this reason, it will be advisable for expression of the viviparous germination capacity to adopt such indications as "Germination Capacity : I_a, II_a, II_b, ..." instead of the simple way of expression "difficult, medium, easy", or the like.

(3) Comparison of germination of seeds between Plot A (coated seeds) and Plot B (stripped seeds).

The result of the experimental test comparing the germination of the seeds in Plot A (coated seeds) with that in Plot B (stripped seeds) on the day of ripening, is given in Figure 2.

In Plot A, the percentage of germination was generally very low, while, as seen in Plot B, stripped seeds showed obviously high percentage of germination and reduced the number of days before germination. This will indicate that the coat of seed plays an important role in the phenomenon of after-ripening of barley. The sections into which Figure 3 is cut up with horizontal lines represent respective different degrees of the so-called viviparous germination capacity, those with vertical lines the different degrees of embryo ripening, and those with oblique lines different degrees of powerfulness of the seed coat to keep in check the growing embryo from germination.

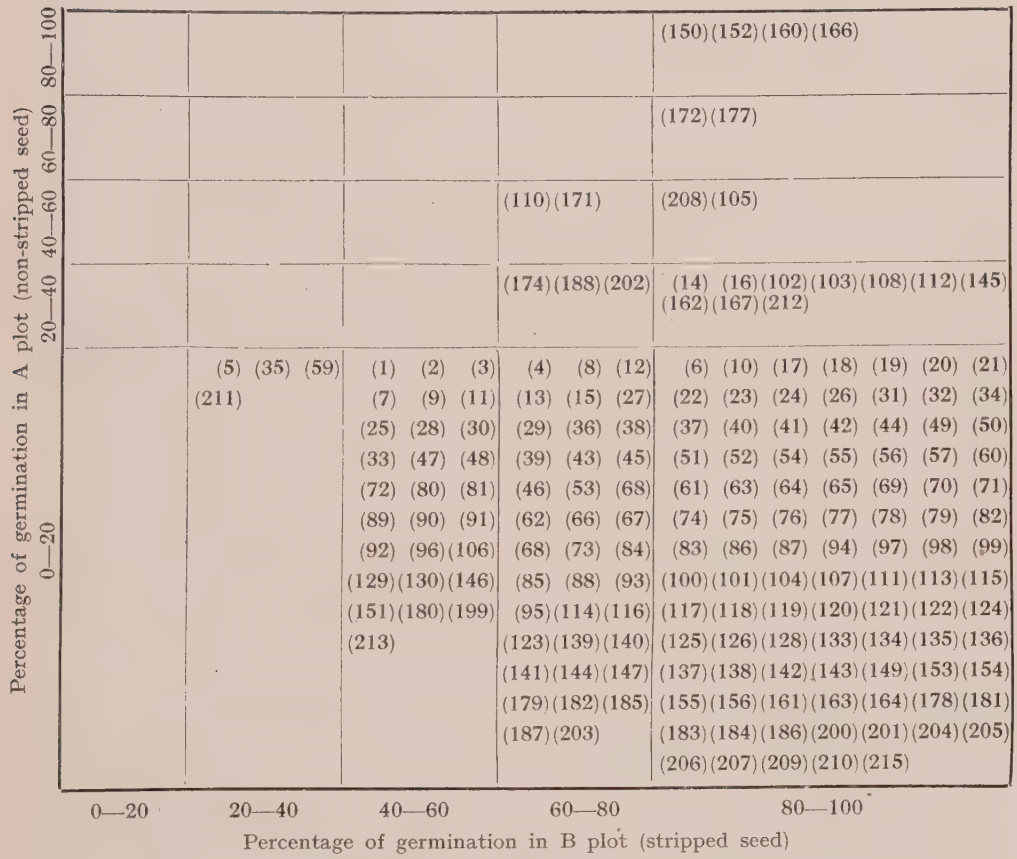


Fig. 2. Varietal difference in the after-ripening of embryo in Barley.

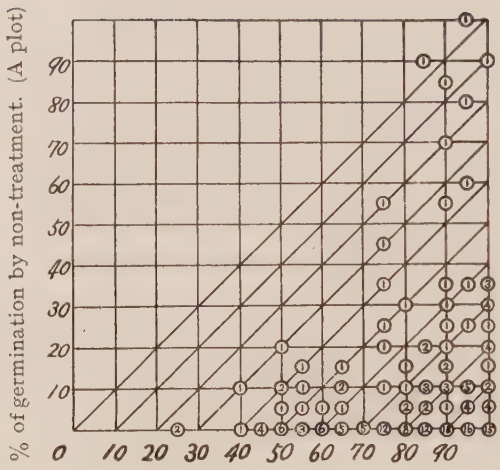


Fig. 3. Classification of the germinate types in barley seed.

II. Germination capacity of barley seed of milk ripening and seed ripening and embryo ripening

The seed can germinate even though it is not perfectly ripe, if its embryo has become ripe. It has been observed of the rice, for example, that some of its seeds are capable of germinating even if cut in the stage of milk ripening, while some others are not unless they spend several days to complete after-ripening even though they appear perfectly ripe.

The seeds of the wheat, barley, and the like generally do not germinate or have a difficulty in germination immediately after being harvested even under most favorable temperature, moisture and light conditions, although they are harvested after they have become apparently ripe. These crops are considered as the ones that require a certain interval of time for completion of the so-called after-ripening of the seeds to secure a perfect germination.

The author recognized this fact in Chapter I, observing that most seeds of the barley immediately after harvest have a dificulty in germination, that there is a varietal difference in the percentage of germination, and that the after-ripening is very obvious as a peculiarity of variety.

As for the varieties of the barley which are hardly capable of germination soon after being harvested, two alternate explanations might be prepared, i. e., that the embryo has not yet become completely ripe even if the seed appears ripe, or that, if the embryo ripening has been completed, any other cause prevents

germination of the seed. But the seeds that are more or less capable of germination at the time they are harvested must have had the marginal period is some earlier time when they first became capable of germinating. The author carried out an investigation to determine about how many days after fertilization the seeds of those varieties of the barley require before becoming capable of germination, and found out from the results of the experiments that the after-ripening in the barley seed is related chiefly to the action of the seed coat. The author's observations will follow :

(1) Germination of seed of milk ripening.

Merry, J. (1941) reported close observations about the morphological development of the embryo of Hordium Sativum L. His report pointed out that the embryo has reached approximate perfection in form and the scutelum has been differentiated by about the eighth day from fertilization, and all the parts of the embroy develop nearly to perfection not later than the tenth to twelfth day. As for the wheat, Nowacky, Kinzel, Whitecomb, and Takahashi have reported that germination occurred between the seventh and thirteenth days from fertilization, Whitecomb (1925) also reported that the first germination occurred in the barley on the thirteenth day. The author's observation at the usual indoor temperature with Sapporo-Rokkaku variety is given in the following table.

Table 2. Germination of barley seed of milk ripening.

a \ b	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		Total
10											1	1				1					3	10
12									1		4			1							6	10
14									1			2	1		1						5	10
16																					0	10
18																					0	10
20																					0	10
22																					0	10
24							1		1												2	10
26																					0	10
28				1																	1	10

Note : Variety : Sapporo-Rokkaku,
a : Number of days after fertilization.
b : Number of days after sowing in seed-bed.

Already on the tenth day from fertilization, three of all the ten seeds germinated, and with the twelfth and fourteenth days the percentage of germination rose, but dropped again thereafter.

Worth coticing were the following :

a) The seeds were found capable of germinating already on the tenth day from fertilization, namely, the seeds probably reached the stage of embryo ripening, in which they were capable of germinating should the external conditions be suit-

Table 3. Germination of barley seed of milk ripening, when stripped.

b \ a	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		Total
10																					1	10
12										2	1			1							3	10
14								1		1											4	10
16							3	1	1												6	10
18			3		2	1	2														8	10
20			4	2	2	1															9	10
22		5		3																	8	10
24		3	1	2	1																7	10
26		3	4		1				1												9	10
28		3	1	1					1												6	10
30		5		2																	7	10
32		3	1	2	2																8	10
34		6	3	1																	10	10
36	3	3	4																		10	10
38	2	4	1		1																8	10
40	2	3	3	1																	9	10

Note : Variety : Tanikaze No. 2.
a : Number of days after fertilization.
b : Number of days after sowing in seed-bed.

Table 4. Comparison of germination in barley between coat-seeds and stripped seeds.

Name		Number of days after sowing in seed-bed. 1	2	3	4	5	6	7	8	9	Number of germinated seeds.	Total number of seeds in seed-bed.
1. Kairyobozu	c	0	0	0	0	0	0	0	0	0	0	10
	s	1	4	5	9	9	9	9	9	9	9	10
2. Shirochinko	c	0	0	0	0	0	0	0	0	0	0	10
	s	3	5	6	9	9	9	9	10	10	10	10
3. Akashinriki	c	0	0	0	0	0	0	0	0	0	0	10
	s	6	10	10	10	10	10	10	10	10	10	10
4. Dairokkaku	c	0	0	0	0	0	0	0	0	0	0	10
	s	0	0	1	3	3	7	7	7	8	8	10
5. Hokudai No.1	c	0	0	0	0	0	0	0	0	0	0	10
	s	2	6	7	9	9	10	10	10	10	10	10
6. Bozuomugi	c	0	0	0	0	0	0	0	0	0	0	10
	s	0	1	1	3	4	5	5	5	6	6	10
7. Tanikaze No.2	c	0	0	0	0	0	0	0	0	0	0	10
	s	0	1	1	1	2	3	4	6	6	6	10
8. Hayakiso No.2	c	0	1	1	2	2	2	2	2	2	2	10
	s	0	1	5	5	7	9	9	9	9	9	10
9. Miyagi No.123	c	0	0	0	0	0	0	0	0	0	0	10
	s	0	2	3	5	7	9	9	9	9	9	10
10. Suigen No. 13	c	0	0	0	0	0	0	0	0	0	0	10
	s	0	1	2	4	4	6	8	8	8	8	10

Note : c : coat-seed. s : stripped seed.

able enough to allow it.

b) The seeds of milk ripening harvested ten dyas after fertilization required 11 – 12 days from sowing in bed to germination, while those harvested more days after fertilization required a shorter interval of days prior to germination.

c) The drop of the percentage of germination after the period of the tenth to fourteenth day, in which the percentage of germination reached its peak, will be explained by the assumption that the seeds passed into the dormant stage.

(2) Germination of stripped seed of milk ripening.

Heinisch, O. (1936) found in relation to the germination of the seeds of milk ripening of the barley that removal of the seed coat could improve the percentage of germination. The author carried out germination tests on the stripped seeds of milk ripening, using the barley seeds of varieties including Tanikaze No. 2. The results of those tests are given in Table 3. It was same as in the previous experiment that the seeds showed first germination on the tenth day. But in this case, any subsequent decrease in percentage of germination was not observed: The percentage continued rising and there were no signes of dormancy. This indicates that the cause for the lower percentage of germination of the seeds nearing to maturity lies in the seed coat.

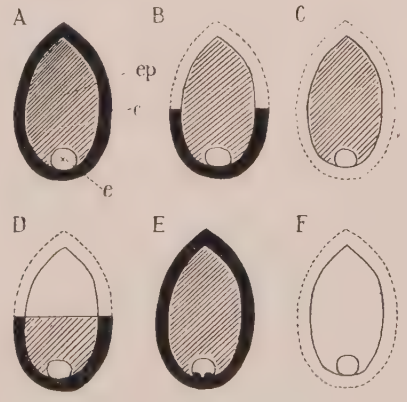
(3) Germination of seed given mechanical treatments on coats.

As it was found that the percentage of germination even of the seeds of milk ripening harvested only tendays after fertilization could be obviously improved by removing the seed coats, the possible effects of various types of mechanical treatments on germination of ripe seeds were put under observation.

The variety of barley used for the purpose was Sangatsu-mugi. The types of treatments given are as follows:

A. No treatment, as harvested.
B. Removal of top half of seed coat.
C. Complete stripping.
D. Cutting off top half of seed.
E. Perforation of seed coat to embryo.
F. Removal of all other parts of seed than embryo.

As Table 5 shows, the seeds of Sangatsu-mugi with their embryo exposed to the atmosphere by such treatment as taking off all the parts of the seed other than embryo or all the seed coat showed the best germina-



Note: c: seed-coat, e: embryo, ep: endosperm.

Fig. 4. Various types of mechanical-treatments of seed-coat in barley.

Table 5. Germination of stripped seeds given mechanical treatments in Barley.

Types of treatments	Total	Number of germinated seeds	Sprout	Root		Variety
A	20	0	0	0	−	Sangatsu-Mugi.
B	20	9	5	9	+	
C	20	10	10	10	+	
D	20	20	20	20	+ + +	
E	20	20	20	20	+ + +	
F	20	20	20	20	+ + +	
A	10	3	1	3	−	Omugi No. 3.
B	10	2	1	2	−	
C	10	4	3	4	−	
D	10	8	8	8	+ +	
E	10	10	10	10	+ + +	
F	10	4	4	4	+	

tion, followed by the ones that were given the treatment of perforation of the coat to bring their embryos into contact with the atmosphere.

In short, it is of no doubt that possibility of succesful germination is influenced by presence or absence of the seed coat, yet a more important factor for a good germination is contact of the embryo with the atmosphere.

The author observed also the difference in the volume of respiration of the seed caused by presence or absence of the seed coat, varietal difference in the volume of respiration, germination percentage of the stripped seeds immersed in the agar solution with only the embryo off over the solution and exposed to the atmosphere and the ones totally buried in the agar, and the process of development and structure of the seed coat of the barley as well as varietal difference in this relation, but failed to find out any cause of varietal difference from the morphological study of the seed coat of the barley.

III. Germination in hydrogen peroxide solution

If the seed of the barley immediately after harvest is stripped and immersed in the distilled water, it shows germination which is correlated to its capacity of viviparous germination, and a varietal difference is observed in this case, too. But the percentage of germination is very low on the whole. When a solution, however, with a touch of hydrogen peroxide was used instead of the distilled water, the percentage of germination was found to be much higher. Furthermore, it was observed that the amount of the hydrogen peroxide (H_2O_2) in the solution was proportionate to the amount added to the pure distilled water, and that the larger the amount of hydrogen peroxide in the solution was, the higher was the germination percentage.

This can probably be explained by the process in which one of the oxygen elements of the hydrogen peroxide (H_2O_2) is supplied to the seed to meet the

want of oxygen required for germination. Therefore, it is easy to expect existence of a varietal difference in oxygen requirements of the embryo for germination.

The author investigated, using three varieties of barley, i. e., Sapporo-Rokkaku, Shin-Omugi, and Bozu-Omugi No. 1, the germination percentages of the seeds harvested just before, thirty days before, sixty days before, and ninty days before, and in the previous year, when put in the hydrogen peroxide solutions of varying concentration : 0.05%, 0.025%, 0.012%, 0.006% and 0.003%, and, as control, in the distilled water.

Table 6. Germination in the various contents of H_2O_2 solution.

Time	Plot	Name	Number of gernimated seeds in various contents of H_2O_2 solution					
			0.05%	0.025%	0.012%	0.006%	0.003%	0%
Day of Ripening	I	1	100.0	100.0	95.4		41.2	35.2
		2	100.0	92.8	58.1		9.3	10.5
		3	100.0	66.3	28.7		0.0	0.0
After 30 days	II	1	100.0	100.0	100.0	94.9		
		2	100.0	100.0	72.4	43.4		
		3	100.0	80.0	41.7	19.2		
After 60 days	III	1		100.0	100.0	100.0	89.0	
		2		100.0	86.2	73.5	48.3	
		3		100.0	68.5	52.6	46.2	
After 90 days	IV	1			100.0	100.0	100.0	98.5
		2			100.0	100.0	97.5	94.6
		3			98.2	100.0	92.7	96.8
After 1 yaer	V	1						100.0
		2						98.8
		3						100.0

Note : 1, Sapporo-Rokkaku 2, Shin-Omugi 3, Bozu-Omugi No. 1.
Number of test-seeds : 300. per plot.

Based on the above results, the following can be stated :

(1) The plot with the seeds harvested just before generally showed difficult germination or low percentage of germination. But the older the seeds were, i. e., 30 days, 60 days, and 90 days old, the higher germination percentage was obtained, and the seeds harvested in the previous year showed a very high percentage even under the distilled water. The stripped seeds sown after the lapse of a reasonable length of interval from the day of harvest germinates with a supplement of least amount of oxygen, but requires a lot of oxygen when sown immediately after harvest, and a lack of it checks their germination.

(2) Even the seeds which have been just harvested and have a difficulty in germination gradually improve their percentage of germination with supply of

hydrogen peroxide solution.

(3) Also in this case, however, there is a varietal difference in the oxygen requirements of the stripped seeds for germination.

IV. Germination capacity of hybrid seeds

Of the tissues composing the seed of the barley, the embryo and endosperm are produced by fertilization, while the seed coat or fruit-skin originates from the tissues of the mother plant. Therefore, if crossing is made between a variety with strong tendency of dormancy and another one with high capacity of germination, whether the hybrid seed produced will show xenia as to the dormancy or not is a matter of importance to make clear the mechanism of the dormancy in the seed.

The heredity of dormancy has to date not been known of many crops. But Nilson-Ehle (1914). Swen (1940), and Oka (1943) reported this phenomenon in wheat, and Johanson (1935) in the oat. Johanson recognized the presentation of xenia in the case of crossing of Avena sativa with A. fatua, reporting dominancy of the character of weak dormancy.

To make clear the cause of the dormancy in the barley, the author selected from among the varieties whose characters had been clearly known from the results of the experiments mentioned in Chapter III the following six varieties on the basis of such characters as strong or weak power of seed coat to check germination and the embryo's large or small oxygen requirements, and made reciprocal crossings among them.

Kochi-Wase	Kobin No. 1	Omugi-Shin No. 1
Miyagi No. 1	Sapporo-Rokkaku	Kinai-Zatsu No. 25

The results showed percentage of germination either intermediate between those of the parents or rather near the higher percentage of one of the parents for the larger part of the hybrid seeds. And the F_2 seeds produced on a F_2 plant showed individually varying percentages of germination, and a considerably wide separation was observed, too.

Table 7. Germination of hybrid seeds in barley.

1. Omugi-Shin No. 1×Aizu No. 6, and its backcross.

Name	Coat-seed		Stripped-seed	
	% of germination	Number of days before germination	% of germination	Number of days before germination
A Omugi-Shin No. 1	36.3	16.0	98.2	5.0
B Aizu No. 6	7.4	18.7	95.5	9.4
A×B	31.1	16.8	100.0	4.7
B×A	12.6	19.2	98.6	5.2

2. Sapporo-Rokkaku × Bozu-Omugi No. 1, and its backcross.

Name	Coat-seed		Stripped-seed	
	% of germination	Number of days before germination	% of germination	Number of days before germination
C Sapporo-Rokkaku	89.4	3.5	100.0	2.1
D Bozu-Omugi No. 1	12.9	19.3	46.2	15.4
C×D	82.6	3.8	84.4	3.2
D×C	53.0	13.4	77.8	6.1
$(C\times D)F_1$	58.0	12.8	83.4	5.4
$(D\times C)F_1$	62.1	14.3	84.1	5.1

First, the reciprocal crossing was made between Omugi-Shin No. 1 and Aizu No. 6. The former had shown medium and easy germination of coat-seeds and of stripped seeds, respectively, and powerful growth of embryo and medium inhibition of germination by the seed coat, while the latter had shown strong growing power of embryo and, at the same time, strong power of seed coat to check germination.

As Table 7 shows, the result of the germination test on A×B was similar to that on A in the coat-seed plot, and, moreover, the F_1 seeds showed even easier germination in the stripped seed plot. And B×A obtained the results approximately intermediate between A and B, seemed to germinate even more easily in the stripped seed plot.

The F_1 seed or hybrid seed is expected to have the character of its mother plant in the seed coat and F_1 character in the embryo.

If we consider the characters determining the capacity of germination of Omugi-Shin No. 1 and Aizu No. 6, distinguishing them into the power of growth of embryo and power of the seed coat to check germination, and indicate the degree of each of them on the basis of the results of the above tests, we can say that the growing power of embryo was found "strong" similarly in A and B, and the power of the seed coat to check germination "medium" in A and "strong" in B.

If a hybrid seed is to show the character of its mother plant in the seed coat and dominant character of any one of its parents or intermediate character in the embryo, it is natural that the power of the seed coat to check germination which is the character of the mother plant, should strongly present itself in germination of a coat-seed, and the character of the hybrid embryo should come out strongly in the case of a stripped seed.

As for crossing between Sapporo-Rokkaku and Bozu-Omugi No. 1, also, coincidence between the theoretical values and the actual results of the tests, when analyzed in the same manner as above, has been observed.

V. Summary

(1) The capacity of viviparous germination was tested on 190 varieties of the barley collected from different sections of Japan. The results of the tests showed an obvious varietal difference in the capacity of viviparous germination. The varieties could be classified into 14 classes according to differences in capacity of the viviparous germination.

(2) The stripped seed plot showed a percentage of germination generally much higher than that of the coat-seed plot. But the percentage of germination of the coat-seed and stripped seed plots were not always in a direct proportion.

(3) The seeds of the barley become capable of germinating on about the tenth day from fertilization, but become lower in the percentage of germination later on the pass into dormancy. Removal of the seed coat, however, can prevent the seed from passing into dormancy and keep the percentage of germination high.

(4) Different types of mechanical treatments were given to the seed coat. Importance of establishment of contact between the embryo and the atmosphere by removing or perforating the seed coat covering the embryo to imporve the percentage of germination was observed.

(5) The structural development of the seed coat of the barley was put under observation to know whether there is a morphological difference among varieties in this relation or not. But no definite conclusion has been reached.

(6) Both the coat-seed and stripped seed showed improved percentage of germination in the solution of hydrogen peroxide, and the extent of such improvement was in direct proportion to the concentration of hydrogen peroxide in the solution. From these results, moreover, it was learned that there is a varietal difference in oxygen requirements of embryo for germination. It can be said that the larger the oxygen requirements are, the lower is the capacity of viviparous germination.

(7) The varieties which had shown difficult germination and those which had shown easy germination were chosen for reciprocal crossing. Xenia was observed in the hybrid seeds produced by the reciprocal crossings, and the results of the tests coincided with the theoretical values in this relation.

(8) There is a varietal difference in the capacity of viviparous germination in the barley. The capacity of viviparous germination is a double expression of the character of the seed coat and that of the embryo.

There are variations in oxygen permeability of the seed coat and also in the oxygen requirements of the embryo for germination. It would be safe to understand that the combination of varietal differences in those characters produce the varietal difference in the capacity of viviparous germination.

Literature cited

(1) Akihama, K. and Wada, E., Ikushu-Tsuho, (1934), 958. (in Japanese)
(2) ————, Agr. and Hort. **11** (1936), 2937. (in Japanese)
(3) Atterberg, A., Landw. Versuchssta. **67** (1907), 129.
(4) Atwood, W. M., Bot. Gaz. **57** (1914), 384.
(5) Harrington, G. T., J. Agr. Res. **23** (1923), 79.
(6) Heinisch, O., J. f. Landw. **83** (1935), I.
(7) ————, Zeits. f. Zücht. A. **21** (1937), 294.
(8) Hiltner, L., Deut. Landw. Gesell. **16** (1901), 192.
(9) Inazuka, G., and Asanuma, S., Agr. and Hort. **13** (1938), 63. (in Japanese)
(10) Kiesling, L., Landw. Jb. f. Bayern. **1** (1911), 449.
(11) Kondo, M., Takahashi, R., und Terasaka, Y., Berich. Ohara. Inst. **7** (1937), 457.
(12) Nilsson-Ehle, H., Zeits. f. Zücht. A. **2** (1914), 153.
(13) Merry, J., Bull. Torrey. Bot. Club. **63** (1941), 569.
(14) Oka, H., J. Soc. Trop. Agr. **15** (1943), 78. (in Japanese)
(15) Takegami, S., Agr. and Hort. **15** (1940), 1445. (in Japanese)
(16) ————, Plant and Zool. **9** (1941), 125. (in Japanese)
(17) Takahashi, R., Proc. Crop. Soi. Soc. Jap. **9** (1937), 45. (in Japanese)
(18) ————, *Nogaku-Ronso.* (1938), 169. (in Japanese)
(19) Whitecomb, W. D., and Sharp, P. F., J. Agr. Res. **31** (1925), 1179.

Isolation Methods of the Soft-Rot Causing Bacteria from the Soil*

Hiroyuki TSUYAMA and Masayuki SAKAMOTO

(Received February 24, 1952)

I. Introduction

Only a few informations have hitherto been given concerning the behaviors of pathogenic bacteria in field soil. This may be partly due to the fact that the isolation of causal organism from the soil has been considered to be technically difficult.

The soft-rot disease of vegetables, which is soilborne, caused by *Erwinia aroideae* Holland, is widely distributed in our country, especially in northern part which gives heavy damages to petsai (*Brassica pekinensis*) cultivation. In an ordinary year the ourbreak of the disease may be seen in the middle of September and becomes destructive in early October. At present no effective method to control it has been found.

Since June of 1950 the authors have been carrying out investigations into the seasonal trend in the number of the soft-rot causing bacteria in field soil.[3] In order to clarify this problem two isolation methods of the bacteria from the soil were adopted, which will be described in the present paper.

II. Isolation methods

Generally speaking, the isolation of bacteria from the soil is attained by the following two procedures: (1) indirect and (2) direct isolations. The former method is based upon the reisolation of a pathogene from the rotted plant tissue by an application of diluted soil solution, as reported by Leach.[1] The latter is attained by the use of a special culture medium, as reported by Patel.[2] Both methods are based upon the principle of utilizing the pathogenic nature to affect living tissue or its specific tolerance to some chemicals in order to eliminate other non-pathogenic bacteria in soil and facilitate isolation of pathogene in question.

1. Indirect isolation method through living plant tissue

As the present pathogene is capable of affecting various kinds of vegetables,

* The 72nd report of the Institute for Agricultural Research, Tohoku University (1952).

any of them may be used as a test material for inoculation. The authors employed carrot roots especially because of their availability at any season of the year.

After surface sterilization with 0.1% aqueous solution of mercuric chloride for about thirty minutes, carrots are cut into slices 0.5 – 1 cm in thickness with a sterilized knife. The slices are arranged in a moist chamber and the inoculum is put on them. The inocula are made as follows : one gram of soil sample is diluted with sterilized water in order of 10^{-1}, 10^{-2},....., 10^{-6}. One cubic centimeter of each diluted soil solution is poured into Petri-dish with aliquot volume of melted bouillon agar. From these agar plates small disks (inocula) are punched out with a sterilized cork-borer (0.9 cm in diameter).

The slices thus inoculated are incubated at 30°C. Observations are made after 2 and 4 days' incubations. Then the rotted carrot-slices are crushed and diluted in a sterilized water, and poured into Petri-dish with modified Drigalski's medium.* On this medium the colony of the soft-rot causing bacteria may be easily distinguished from the other. By the results of the carrot-slice tests conducted at different periods of the year confirmation was given on the existence of the soft-rot causing bacteria in field soil.

Table 1. Percentages of the rotted carrot-slices inoculated with field soil solutions of different dilutions (30°C)

Sampling date	After 48 hours						After 96 hours					
	Dilution						Dilution					
	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}
1950												
June 14	100	100	100	100	0	0	100	100	100	100	0	0
July 18	0	0	0	0	0	0	100	100	67	33	0	0
July 31	0	0	0	0	0	0	0	0	0	0	0	0
Aug. 8	0	0	0	0	0	0	0	0	20	0	0	0
Sept. 5	0	0	0	0	0	0	0	0	0	0	0	0
Sept. 28	20	0	0	0	0	0	20	0	0	0	0	0
Oct. 24	0	0	0	0	0	0	40	20	20	0	0	0
Nov. 14	30	0	0	0	0	0	40	80	30	0	0	0

The tissue of rotted carrot-slice softens and becomes watery, and gives out a characteristic oder. However, the symptoms appeared on the carrot-slices applied with the soil solution would not necessarily coincide with those mentioned above. They were distinguished from one another into the following four types :

(a) the type in which rotted portion softens, becomes watery and amber-color, as in the case by the affection by *Erwinia aroideae* ;

(b) the type in which rotted portion blackens ;

* This medium will be discussed later.

(c) the type in which rotted portion thoroughly collapses;
(d) the type in which only the portion under the inoculum blackens and no further rotting develops.

However, after several reinoculation successively on fresh carrot-slices, the symptoms of types b, c and d, will have a close resemblance to those of type a, as shown in Talbe 2.

Table 2. Change of the symptoms appeared on carrot-slices through successive reinoculation* (30°C)

No. of slice	Inoculation of diluted soil solution (Jan. 29)	Reinoculation I (Jan. 31)	Reinoculation II (Feb. 2)
1	Thoroughly rotted, blacken	Rotted, watery, amber-colored .... 2 Rotted, blacken 1	Rotted, watery, amber-colored 3
2	Rotted, watery, amber-colored	Rotted, watery, amber-colored .... 1 Rotted, blacken 1	Ditto 3
3	Partly rotted, blacken	Rotted, watery, amber-colored 3	Ditto 3
4	Ditto	Rotted, watery, amber-colored .... 1 Rotted, watery, blacken 1	Ditto 3
5	Partly rotted, amber-colored	Did not rot	Did not rot
6	Ditto	Rotted, watery, amber-colored .... 1 Rotted, blacken 1	Rotted, watery, amber-colored 3

* Three slices were used.

And all the bacteria, causing the rot of type a, showed an identical development on bouillon agar plate. Therefore, it may be considered that the above mentioned differences in the symptoms on carrot-slices should have been due to the influence of other non-pathogenic bacteria in soil.

2. Direct isolation from the soil

Patel[2] successfully isolated *Agrobacterium tumefaciens* and *Erwinia carotovora* from field soil by using bile agar medium. The authors empolyed modified Drigalski's agar medium, which had been originally used for the isolation of intestinal bacteira. The component is as follows:

Bouillon agar	1 litre
Lactose or glucose	10 g
Crystal violet (0.1% aq. sol.)	5 cc

Bromthymolblue (0.2% sol.) 40 cc
(pH of the medium is adjusted at 7.0 – 7.2)

As crystal violet (triphenylmethane pigment) has been known to inhibit the growth of Gram-negative group of bacteria, its addition to the medium is effective in eliminating them, found in a large number in field soil, in an isolation procedure. It has been also known that *E. aroideae* easily produces acids from various sugars. Bromthymolblue added to the medium can tell us such acid formation by color change in the conlony from blue to yellow. On this medium the colonies of *E. aroideae* showed first a yellow color, having a yellow nucleus and transparent margin, then turned to greenish yellow and finally green to blue. The densely distributed colonies and the medium around them showed more rapid change in color than sparsely distributed.

The results of the isolation tests of the soft-rot causing bacteria directly from field soil by modified Drigalski's medium will be given in the following paragraphs.

The concentrations of diluted soil solutions used in these tests were 10^{-5} and 10^{-6}. The bacterial strains appeared on the medium were selected according to the color of their nuclei, viz., yellow, greenish yellow, green and blue.

The isolates, after 3 days' incubation at 30°C on bouillon agar slant, were examined for their rot-causing abilities by carrot-slice test. The results are shown in Tables 3 and 4.

As shown in Table 4, colonies of the most of the soft-rot causing strains showed a yellow or greenish yellow color, and during 5 days' incubation they did not turn to blue. However, the color of colony in every strain showed a

Table 3. The number of the isolates by modified Drigalski's medium and the soft-rot causing strains among them.

Sampling date	A soil		B soil	
	Total number of isolated strains	Number of the soft-rot causing strains	Total number of isolated strains	Number of the soft-rot causing strains
1950				
July 4	23	0	0	0
Aug. 18	17	0	6	0
Sept. 5	12	0	12	1
Sept. 12	5	0	19	6
Sept. 26	11	1	21	8
Oct. 26	12	2	28	2
Nov. 12	15	0	35	1
Dec. 9	13	0	24	0
1951				
Jan. 23	13	1	53	4
Feb. 15	4	1	37	2
March 17	16	1	17	1
April 16	17	0	24	0

Table 4. The color of colonies of the soft-rot causing strains shown on modified Drigalski's medium (5 days' culture, 30°C)

Sampling date	Color of colony		
	Yellow-greenish yellow	Green	Blue
1950			
Sept. 5	1	0	0
Sept. 12	3	3	0
Sept. 26	9	0	0
Oct. 26	3	1	0
1951			
Feb. 15	2	2	0
March 17	1	0	0
Total	19	6	0

gradual change from yellow to blue ; when colonies were densely distributed such color change was especially accelerated. So the selection of the causal strain should be made at an early incubation period.

The number of the isolates which had a yellow or green nucleus and of the soft-rot causing strains among them in several isolation tests is show in Table 5.

Table 5. Color of colonies and soft-rot causing abilities of the isolated strains.

Sampling date	Number of strains showed yellow or green colored colony	Number of rot-causing strains
1950		
July 14	3	0
Aug. 18	20	0
Sept. 5	15	1
Sept. 12	18	3
Sept. 26	24	9
Oct. 26	15	3
1951		
Feb. 15	6	2
March 17	8	1
Total	109	19

As shown in the above table, the percentage of the latter to the total isolates is not high (17.4%). It can be said, however, that an isolation of the soft-rot causing bacteria from field soil by the use of modified Drigalski's medium may be attained more successfully, if proper dilution of soil solution, duration of incubation period, and other characteristic appearance of the colony, such as a transparency at marginal part, are taken into consideration.

References

(1) Leach, J. G., Phytopath. **20** (1930), 215.
(2) Patel, M. K., Phytopath. **19** (1929), 295.
(3) Tsuyama, H., Sakamoto, M., Bull. Inst. Agr. Res. Tohoku Univ., Japan, **3** (1951), 13. (In Japanese with English résumé.)

The Distribution of the Injured Ears in the Rice Field Attacked by Rice Stem Maggot, *Chlorops orizae* Matsumura, and Estimation of Optimum Size of Field-Plot*

Mikio KANDA

(Received November 1. 1951)

I. Introduction

It seems needless to say that, in carrying out a field experiment on insect control or in making selection of resistant strains to insect infestation as a step of breeding work to develop new varieties, how to draw up the experimental design becomes a very important problem, because it has much to do, in discussion of the experimental results, with the amunnt of informations or the precision of the experiment. For this reason, suggestions have often been made that for a field which is to be used for experiments a uniformity study be condusted. For an experimental worker who deals with insect infestation, therefore, it seems to be one of very important fundamental problems to investigate the nature of the distribution of insect populations in the experimental fields and the relation between the experimental design and the distribution of insect populations, and to establish a basic estimate for optimum field-plot size and shape as well as suitable experimental design.

This sort of study, moreover, will give not a little contribution to other entomological studies.

Many studies and investigations, up to this time, have been conducted in trial to apply mathematical equations to the field distribution of insect populations on the basis of statistical probability conceptions. Among these, the studies of "Student"[11] (1907), Neyman[8] (1939), Beall[1] (1940), etc. are outstanding. Recently, in Japan, Uchida[12] (1951), working with the common cabbage worm (*Pieris rapae* L.), 28-spotted lady beetle (*Epilachna sparsa orientalis* Dieke), larvae of the rice stem borer (*Chilo simplex* Butler), and cowpea weevil (*Callosobruchus chinenesis* L.), has examined the form of spacial distribution by comparing

* The 66th report of the Institute for Agricultural Research, Tohoku University (1951).

the observed with the theoretical values of probability pattern. Ii and Kamano[5] (1951) have reported that the field distribution of the number of injured stems per hill well fitted to the theoretical values of Pólya-Eggenberger's frequency distributions.

With respect to the optimum plot size and shape or to the suitable design to be adopted in field experiments on insect infestation, on the other hand, only a little literature has been published as far as the writer is aware. Bowen[2] (1947) has studied the nature of distribution of the beet leafhopper (*Eutettix tenellus* (Baker)) in a particular field of sugar beet (*Beta vulgaris* L.) on different dates, and has determined, based on the data obtained by sampling beet-field populations, the relation between the experimental design and the distribution of insect populations. Ii and Miyashita[4] (1951) have investigated, in order to find out the proper size and shape of plots to be used in field experiments for determining the relative merits of different insecticides for control of rice stem boreres, the coefficients of variation within plot for injured stem numbers per hill on various plots of different sizes and shapes.

In the course of study on the inheritance of resistant character in rice varieties to the rice stem maggot (*Chlorops orizae* Matsumura), by the reasons already mentioned, the writer had felt the necessity, as one of basic problems, of clarifying the nature of the distribution of the injured ears attacked by rice stem maggots in the paddy fields and of determining the relative efficiencies of plots of varying size and shape to be used in agronomic trials with the insect. In cooperation with the Tohoku Agricultureal Experiment Station, Omagari, Akita, the writer carried out uniformity trials in the experimental paddy fields at the station.

The nature of the distribution of injured ears in paddy fields was studied, and, on the basis of the data obtained by sampling paddy field populations, the relation between experimental design and the distribution of injured ears was determined.

The report presented here is the outline of the results of the trials in 1950. The writer hopes that the following will give any contribution to experimental workers.

Acknowledgement : Before proceeding further, the writer wishes to express his thanks to Messrs. Y. Tokunaga, M. Okada, and Z. Yamashita, Technical Officers of the Tohoku Agricultural Experiment Station, Ministry of Agriculture and Forestry, for their valuable suggestions and aids.

II. Materials and Methods

Two experimental paddy fields, approximately 0.05 acres each in area and neighboring each other, planted with the rice varieties Rikuu No. 132 and Ou No. 195 comparatively susceptible to the rice stem maggot, respectively, were used for the uniformity test.

The rows were spaced about 10 inches and the rice plants were spaced about 6 inches apart along the rows. The plants were cultivated according to the standard cultural operations, and the fields were handled in as uniform a manner as possible under the common field management.

Total unmber of ears and number of injured ears were counted for each individual plant throughout fields, and the actual distributions of injured ears were obtained. The data obtained in each field were examined by x^2 for its agreement with various theoretical distributions.

In order to determine the effect of plot size and shape on the between-plot (within-block) variation, and to study the relative efficiencies of plots of varying size and shape and to determine the most efficient size and shape of plot to be used for field experiments on the insect inferstation, each field was divided into 640 plots of same size and shape, without border rows, each 2.5 feet long and 10 inches (1 row) wide, and the data for these plots were then recombined in such a manner as to make up plots of different sizes and shapes. Thirteen size-shape combinations were studied. These are illustrated in Table 1 and Figure 1.

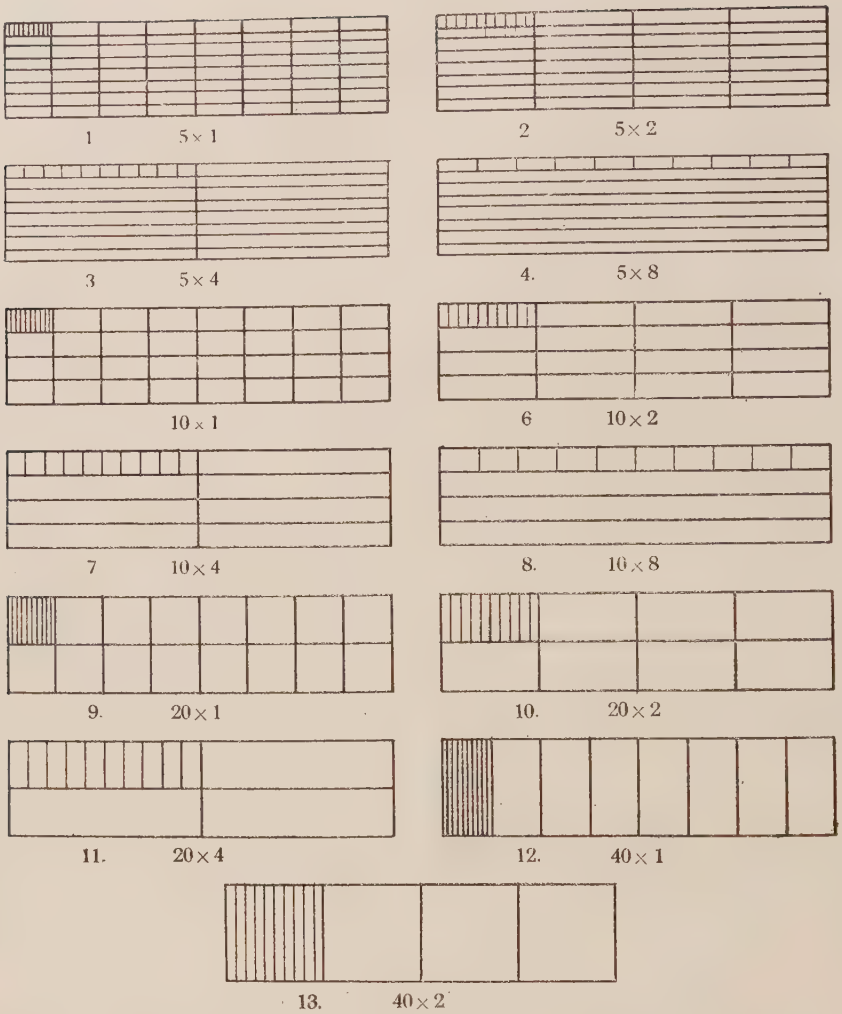
The analysis of variance method was used for analyzing the data. The statistical techniques employed will not be mentioned here to avoid superfluity as they have already been discussed thoroughly by many workers and reported in various publications. The analysis of variance was made on the assumption of ten varieties or treatments to be tested. The experimental design is under application of the randomized blocks. All of these analysises are on the single-sample basis.

In the study the injured ear was taken as the indicator for the extent of damage inflicted by the rice stem maggot upon the rice plant for convenience, although there seems to be some room for dispute as to whether the damage can be perfectly represented numerically by such an indicator as the number of

Table 1. The Various sizes and shapes of plots studied.

		Width of plot (number of rows)			
		1	2	4	8
Length of plot (number of hills)	5	64	32	16	8
	10	32	16	8	4
	20	16	8	4	—
	40	8	4	—	—

Note: Figures in the table denote replications.



Note: Numbers under each figure denotes the plot length (hills) and width (rows)

Fig. 1. Some of the various sizes and shapes of plots obtained by different combinations of the original 640 plots.

injured ears alone.

Okamoto[9] (1949) has enumerated various units for describing the extent of damage by the rice stem maggot when the injured ear was taken as the damage indicator, and has referred to the advantages and disadvantages of each of them. The writer, also, has felt the illogicality of using the injured ear percentage (number of injured ears/total number of ears) which has usually been used as the unit of describing the extent of damage. The injured ear percentage should be

used as the unit only when there is correlation between the number of injured ears and total number of ears.

It seems to be comparatively appropriate to use the number of injured ears per unit area as the unit of indicator in cases where the injured ear is taken as the indicator for the amount of damage. When the crop is planted regularly with equal spacing throughout the field, as is usually the case, the unit area can be substituted for by the number of hills. In this study, therefore, the number of injured ears per hill was taken as the unit of the indicator.

III. Nature of the Distribution of Injured Ears

The nature of the data suggests such a discontinuous distribution as to be described by a Poisson series or a negative binomial distribution. Comparisons of the observations with the theoretical Poisson frequency distributions for the both fields are given in Table 2, along with the fitting of the data to the negative binomial distributions. The x^2 value in each case denotes a significant disagreement between the observed and calculated values for the field planted with Ou No. 195. For the field planted with Rikuu No. 132, however, the observation data do not agree with Poisson series but show a pretty good agreement with the negative binomial distribution.

In the case of the field planted with Ou No. 195, the observed distribution shows a curve decreasing simply, and the nature of this distribution is somewhat different from that of Rikuu No. 132. The relation between x and $\log f(x)$ is shown

Table 2. Distribution of injured ears for whole field classified according to the number of injured ears on a plant.
(Fitted Poisson and negative binomial distributions, and test of goodness of fit)

Class	Rikuu No. 132			Ou No. 195		
	Frequency			Frequency		
	Observed	Calculated		Observed	Calculated	
		Poisson	Negative binomial		Poisson	Negative binemial
0	1594	1633.25	1565.60	1930	1866.75	1878.07
1	1919	1943.58	1961.83	1878	1978.84	1980.46
2	1252	1156.48	1238.88	1080	1048.70	5100.86
3	466	458.51	449.92	371	370.22	366.45
4	111	136.37	122.95	113	98.08	91.67
5	22	32.21	25.23	13	20.48	
6	3			2		
7	1 } 5	} 8.60	} 4.59	0 } 4	} 6.93	} 5.38
8	1			1		
9				1		
	m=1.19 V=1.13	h=1.19 $P_{x^2}<0.01$	h=1.19 d=−0.05 $P_{x^2}\fallingdotseq 0.3$	m=1.06 V=1.09	h=1.06 $P_{x^2}<0.05$	h=1.06 d=0.003 $P_{x^2}\fallingdotseq 0.05$

by a parabollic curve (see Figure 2). In this figure x denotes the class value, and $\log f(x)$ the value of frequency by logarismic transformation.

The distribution, therefore, seems to be a sort of exponential distribution.

From the data available, however, it can not be determined whether or not such difference in nature of distribution between varieties as described above is an essential one. Further studies are necessary to decide this point.

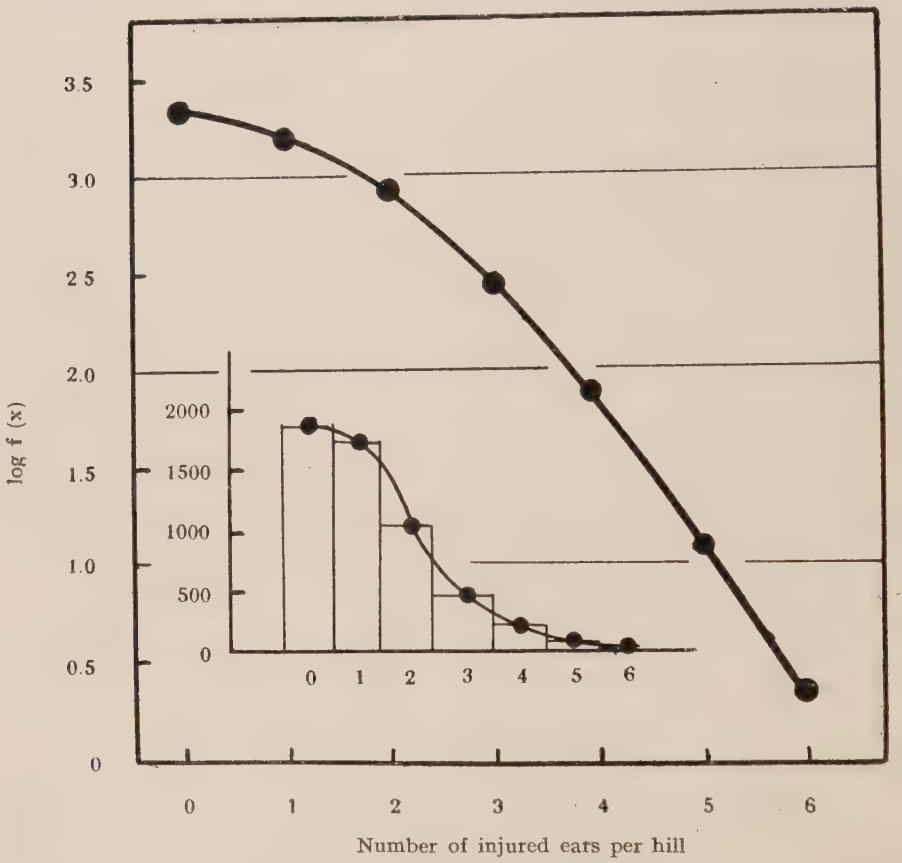


Fig. 2. Distribution curve of number of injured ears per hill (Ou-no. 195)

Each field was divided into 10 rows wide and 10 hills long equal-sized sections, and 5 sample sections (sample size 100) were taken from among these at random to determine the nature of the distribution of the injured ears for these samples.

An attempt to fit the data for each sample to a Poisson series was successful, though there were significant differences in the mean value among the samples. This is illustrated by comparing the observed with the calculated Poisson law

values and the calculated values of W in the Pitman test (Kitagawa[7] 1951), as given in Table 3.

As described later, the analysis of variance of the 10×1 plots (Table 4), which denotes a difference between blocks barely exceeding the 5 percent level of significance, also suggested a greater variability among the block means than would be expected if the distribution of the injured ears was purely random. In this connection, Bowen's data on the beet leafhopper (1947) likewise have been found to show a highly significant variation between plots (1/8 acres).

The facts mentioned above lead to the conclusion that, in the small divided cells within the field, the distribution of the injured ears is essentially in accordance with the Poisson law. Between these cells, however, there is a significant variation in the mean value, and local stability of mean value is lacking. Accodringly, it seems that the frequency distribution of injured ears for the whole field already described is in accordance with the compound Poisson distribution (Kitakawa[7]) 1951).

The preceding discussion indicates that there is a tendency for the injured ear population to depart from a Poisson distribution in a field of considerable size. It would be reasonable to expect that the actual distribution of injured ears will

Table 3. Distribution of injured ears for small divided sectons in the field.
(Fitted poisson distributions and test of goodness of fit)

Class	Sample 1		Sample 2		Sample 3		Sample 4		Sample 5	
	Obs.	Poi.	Obs.	Poi.	Obs.	Poi.	Obs.	Poi.	Obs.	Poi.
Field planted with Rikuu No. 132										
0	27	33	22	27	24	28	23	29	26	28
1	42	37	43	35	30	36	44	36	40	36
2	24	20	20	23	27	23	20	22	20	23
3	6	8	13	10	12	10	12	9	10	9
4	1	2	1	3	2	3	1	4	4	4
5			1	2						
W=0.1357	m=1.12 V=0.66 P_{x^2}≒0.5		m=1.31 V=1.34 P_{x^2}≒0.2		m=1.28 V=1.41 P_{x^2}≒0.6		m=1.24 V=0.95 P_{x^2}≒0.2		m=1.26 V=1.16 P_{x^2}≒0.8	
Field planted with Ou No. 195										
0	38	35	36	32	36	35	41	38	33	31
1	29	37	33	37	34	37	35	37	30	36
2	26	19	19	21	23	19	14	18	25	21
3	4	7	7	8	3	7	6	6	10	8
4	3	2	4	2	4	2	4	3	2	4
5			1							
W=0.1400	m=1.05 V=0.96 P_{x^2}≒0.2		m=1.13 V=1.33 P_{x^2}≒0.6		m=1.05 V=1.06 P_{x^2}≒0.7		m=0.97 V=1.14 P_{x^2}≒0.7		m=1.18 V=1.12 P_{x^2}≒0.6	

depart from a Poisson series because of many factors, both physical and biological, that may operate to disturb a perfectly independent distribution of injrued ears, although it is still unknown what the principal factors are. Yuasa and Koyama[13] (1939) have suggested that the rice stem maggot has some selective ability for environmental conditions. And, thus, it is probably logical to believe that such sensibility of the insect caused heterogeneity of distribution.

The data shown in Table 2 indicate that there are individual plants or certain locations within the fields which may be more attractive or more unfavorable to imagoes or larvae of the insect than others, which condition would upset an independent random distribution and cause the excesses in the small or large frequency classes that usually have been observed in such distributions as departing from a Poisson series.

In this connection, it might be possible that soil heterogeneity greatly influences the distribution of the insect (imagoes or larvae) populations indirectly through its action upon the plants on which the insect lives.

In consideration of the fact that such heterogeneity of distribution is observed even in fields handled as uniformly as possible and planted with a certain same variety, it seems that the selective ability of the insect for environmental conditions might be very high. It is very interesting to try to find out what kinds of environmental factors produce such disparate populations within the fields.

IV. Variation Between and Within Blocks, and Optimum Size and Shape of Field-Plot

The data for the 640 plots may be combined to form plots of various sizes and shapes. Thirteen of these size-shape combinations were studied, as already illustrated in Table 1 and Figure 1. Each block was constructed with 10 plots, as hypothetical varieties or treatment, arranged in parallel.

The variances (shown as C.V.) within and between blocks were computed for each arrangement from the data for each field, as given in Table 4.

Theoretically, the method of analysis of variance is based on the assumption of normal distribution. Often this assumption does not hold for field data. Since the distribution of the injured ears is in agreement with the Poisson law, and deviates significantly from the normal distribution, the application of analysis of variance to it is open to question.

For all practical purposes, however, it has already been demonstrated that the variance method, when applied to a test of significance, will give reliable results, even if there is a considerable degree of skewness in the data.

In addition to the assumption of a normal distribution, the validity of the generalized standard error derived from a combined analysis of variance is based

Table 4. Analysis of variance of different size-shape plots.

Size and shape of plot		Variance	
Length × Width (hills) (rows)	Area (*tsubo*)	Between plots (%)	Within plots (%)
Field planted with Rikuu No. 132			
5 × 1	1/18	62.01 (63)**	40.18 (576)
〃 × 2	1/9	43.11 (31)**	27.21 (288)
〃 × 4	1/4.5	37.86 (15)**	24.26 (144)
〃 × 8	1/2.25	26.55 (7)	20.49 (72)
10 × 1	1/18	48.52 (31)**	30.65 (288)
〃 × 2	1/9	31.63 (15)	24.26 (144)
〃 × 4	1/4.5	28.36 (7)	19.55 (72)
〃 × 8	1/2.25	21.56 (3)	15.42 (36)
20 × 1	1/18	37.29 (15)**	22.46 (144)
〃 × 2	1/9	22.86 (7)	18.89 (72)
〃 × 4	1/4.5	23.30 (3)	13.64 (36)
40 × 1	1/18	18.38 (7)	15.28 (72)
〃 × 2	1/9	4.95 (3)	14.54 (36)
Field planted with Ou No. 195			
5 × 1	1/18	52.59 (63)	49.07 (576)
〃 × 2	1/9	35.79 (31)	33.74 (288)
〃 × 4	1/4.5	24.51 (15)	25.07 (144)
〃 × 8	1/2.25	14.02 (7)	19.77 (72)
10 × 1	1/18	47.66 (31)*	36.17 (288)
〃 × 2	1/9	34.32 (15)*	25.34 (144)
〃 × 4	1/4.5	18.23 (7)	20.93 (72)
〃 × 8	1/2.25	12.38 (3)	14.92 (36)
20 × 1	1/18	37.53 (15)*	27.12 (144)
〃 × 2	1/9	28.34 (7)*	19.19 (72)
〃 × 4	1/4.5	13.82 (3)	13.96 (36)
40 × 1	1/18	28.88 (7)**	16.82 (72)
〃 × 2	1/9	22.07 (3)**	10.88 (36)

Note: 1. Figures in parentheses denote degrees of freedom.
2. Asterisks show significance level.

on the assumption which may be violated for data of the Poisson type. The variance in a Poisson distribution is not independent, but is equal to the mean.

Thus, if population heterogeneity is involved, or if different treatments produce a significant effect, the respective means and, consequently, the variances will be different, and, therefore, combined analysis of the data will be unwarranted.

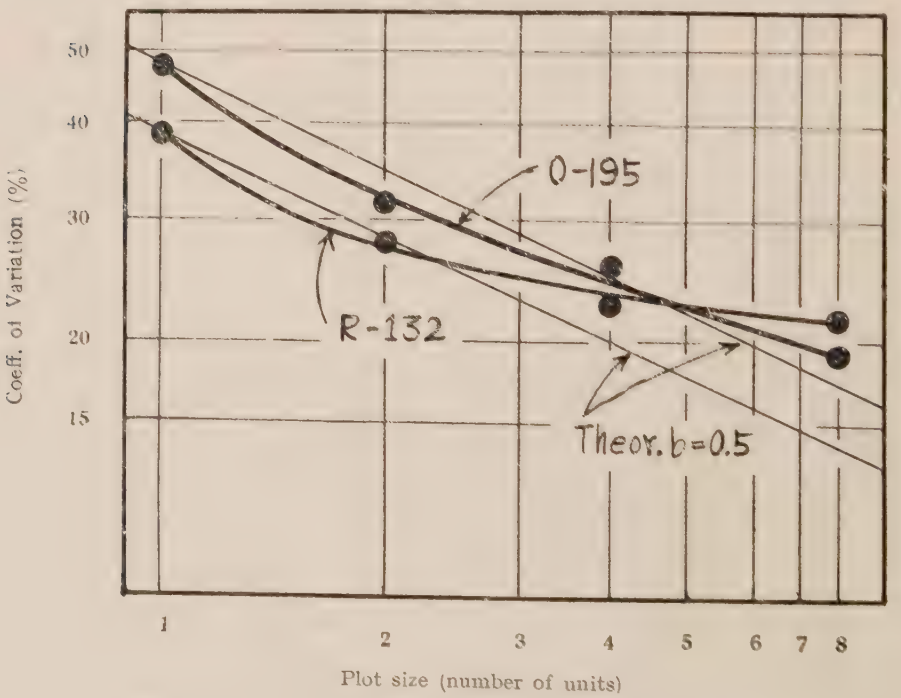
Considerable caution should be exercised in the analysis and interpretation of such data. Otherwise, misleading conclusions may be drawn. For data of the Poisson type, it has been discussed thoroughly that a square root transformation should be applied to equalize the variance before proceeding with the analysis. For plot counts between 10 and 100, the simple square root transformation ($\sqrt{x}$), and for plots the majority of which shows the totals under 10, the transformation $\sqrt{x+0.5}$ is recommended.

In such a particular study as deals with uniformity data, differential variability often will be negligible, and, therefore, a transformation of data is considered unnecessary. However, when different treatments or varieties (In uniformity trials, treatments or varieties are purely hypothetical.) are employed, then differential variability may be introduced by them, and require the transformation.

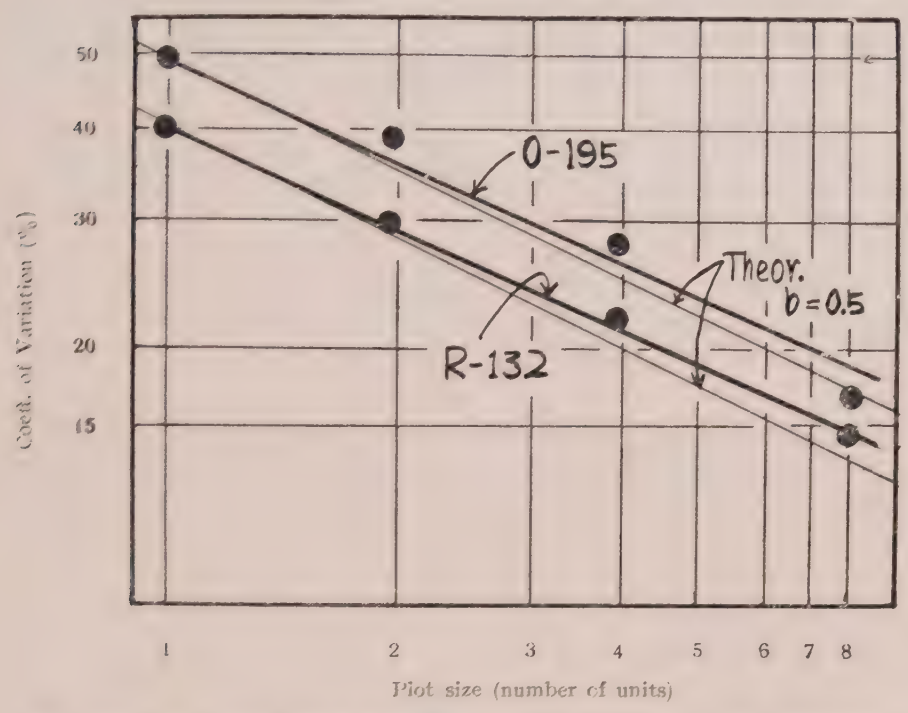
In the present study, the data besides not being normal, show considerable heterogeneity and are of such a type that the variance and the mean are related, the square root transformation, therefore, was used before proceeding with the analysis of variance for accuracy, in spite of the differences in variability do not seem so great as to affect appreciably reliability of the results even if the analysis is made on the original data in the present study.

These analysises were made to determine the effect of plot size and shape on the within-block variation, which is a measure of the experimental error, and to test whether or not population heterogeneity was a significant factor affecting injured ear unmbers on the different plots, and whether or not local control produced a substantial effect on reduction in the estimate of experimental error.

There is a tendency for the within-block variance to decrease as the plots become larger, and this effect is so remarkable that change of the size of plot



a) When the plot length is kept constant and plot width is increased.



b) When the width of plot is kept constant and the length of plot is increased.

Fig. 3. Relation between increase of plot size and coefficients of variation within block.

evidently gives marked effects on the reduction of the experimental error. Every value of variance within block for various plots of different sizes and shapes, however, is very high as compared with the corresponding value of that for grain yield (Kanda[6] 1950).

Observed as well as theoretical decreases in variance within blocks with increase of plot area are illustrated by graphs of log-log scale in Figure 3. The tendency is approximately the same for all the fields.

When the plot length (row length) is kept constant and the plot width (number of rows) is increased to varying extent, it is observed that, as the plot size becomes larger, the variance within block decreases gradually. Such decrease of variance is rapid in the beginning but becomes remarkably slack after the plot area is increased to a certain point, as compared with the theoretical values of decrease. In contrast, if the width of plot is kept constant while the length of plot is increased to varying degree, the decrease of variance shows an approximate agreement with the theoretical values.

These facts indicate that occurrence of injured ears was independent from each other in the direction parallel to the row, that is to say, the insect infestation across the experimental field was essentially uniform in the direction parallel to the row, and, therefore, the usefulness of local control when applied to it may be very questionable. But in the direction rectangular to the row, there is a close dependence of injured ear occurrence on the preceedings. In other words, population heterogeneity exists there, and, therefore, local control will effect a substantial reduction in the estimate of experimental error in that direction.

Bowen[2] (1947), in an analysis of data on the distribution of the beet leafhopper, also shows the presence of a definite population gradient across the field in the parallel direction to the rows, but no definite gradient in the rectangular direction.

In this connection, with the view to numerical comparison of the differences in the degree of the correlation between plots by the directions, the values of regression coefficients (b) were calculated by the equation (Rock and Rigney 1951) :

$$\log \text{C.V.}_x = \log \text{C.V.}_s - \text{b} \log x$$

These calculated values follows :

Field planted with Rikuu No. 132	Direction parallel to the row	b=0.49
	Direction rectangular to the row	b=0.29
Field planted with Ou No. 195	Direction parallel to the row	b=0.49
	Direction rectangular to the row	b=0.44

The land efficiency was calculated for each of the plots of varying size and shape by comparing the variances per unit area of plots differing in size and shape by the method as described by Immer et. al.[5] (1933). A single-unit-plot basis for the study was secured by multiplying the variances per plot by the number of units (5 hills long single row) involved in each plot. Accepting the variance whithin blocks of five hills long single-row plots as a standard, the land efficiency of plots of other sizes and shapes was determined by dividing the variances of plots of various sizes and shapes calculated on a unit basis by the variance of a five hills long single-row plot. Table 5 shows the land efficiencies of these plots in each field.

The land efficiency showed a higher value on the 5 hills long 2-row plot than that on any other plot and decreased generally as the size of plot increased, although exceptionally in the field planted with the variety Ou No. 195 both of the 40 hills long single- and two-row plots showed comparatively high efficiency.

From the viewpoint of land efficiency, therefore, the data presented in this paper, as similarly as the observations in the cases of many other experi-

mental fields, have also indicated that it would be more advantageous to use small plots and replicate sufficiently to reduce the error to the level desired, than to use larger plots and fewer replications.

Table 5. Land efficiency for plots of different sizes and shapes.

Length of plot (hills)	Width of Plot (rows)			
	1	2	4	8
Field planted with Rikuu No. 132				
5	100	105	83	69
10	93	83	73	65
20	89	75	74	
40	93	69		
Field planted with Ou No. 195				
5	100	101	98	88
10	96	82	83	82
20	89	90	88	
40	103	112		

By doing so, the total area of land required for the experiment would be kept at the minimum.

Because, as previously described, the mean square per single plot of variation within blocks for each of the plots of different sizes and shapes was markedly greater than in other agronomic trials, if higher precision of experiments is required from the necessity of the study, for example, to reduce the error variance to the level of 5 percent, and when the five hills long two-row plot, which is considered to be the most efficient size from the present study, is used, as many replications as about 36 times are necessary.

However, such might be too troublesome for experimental workers to do. It would be more practical, therefore, to use larger plots and fewer replications, even at some sacrifice of land efficiency.

In as much as the data considered in this paper indicate that the estimate of experimental error is significantly large, reduction of variance between plots as a means of increasing the precision of the experiment not only from the statistical point of view but also by methods of agronomic and entomological error control is of prime importance.

It is, however, not definitely known what environmental factors, physical and biological, operated to increase the variance within blocks. Further studies, therefore, are needed to gain knowledge about these factors.

In concert with advances in entomological and agronomic researches on the insect infestation, it is desired that the method for controlling such experimental error be established for the benifit of field experimental workers.

Additionally, in an experiment on insect infestation in which many varieties with different responses of resistance to insect infestation are planted across the field proceedingly, it is reasonable to expect occurrence of the competition as shown in other agronomic trials. It is undesirable to use single-row plots in such experiment.

Summary

The nature of the distribution of the injured ears in paddy fields and the proper size and shape of plots to be used in experiments on the insect infestation have been studied by analyzing uniformity data obtained from sample field populations of the injured ears attacked by rice stem maggots (*Chlorops orizae* Matsumura).

The uniformity trials were conducted in two experimental paddy fields, one of which was planted with rice variety Rikuu No. 132 and the other with Ou No. 195, at the Tohoku Agricultural Experiment Station, Omagari, Akita.

The report presented here is the outline of the results of the trials in 1950.

The results obtained are summarized as follows:

1. The distribution of the injured ears in small divided cells of field were in good agreement with theoretical values of Poisson distribution.
2. There are significant differences in average number of injured ears between cells, and the local stability of mean value is lacking.
3. The distribution of injured ears in the whole field is not in agreement with Poisson distribution. The distribution can be regarded as a summation of Poisson distributions having different mean values.
4. On account of the results of analysis of variances for the plots of varying size and shape, coefficients of variation within blocks are very large in comparison with the cases of other agronomic trials. In this sort of experiments, it is hard to avoid a large error that accompanies it.
5. The heterogeneity of injured ears in paddy field is high through the direction rectangular to the row as compaired with the parallel one.
6. From the viewpoint of the land efficiency, 5 hills long 2-row plot is more useful than any of the others as a whole, but in consideration of plot management operations, it seems practical to use a larger plot.
7. This paper considers the field plot lay-out solely from the viewpoint of the distribution of injured ears, but attention is called to that other considerations also may be of importance.

Literature Cited

(1) G. Beall, *Ecology*, **21** (1940), 460.
(2) Myles P. Rowen, *Jour. Agr. Res.*, **75** (1947), 259.
(3) M. Ii and S. Kamano, *Oyo-Kontyu* (in Japanese), **7** (1951), 70.
(4) M. Ii and K. Miyashita, *Oyo-Kontyu* (in Japanese), **7** (1951), 69.
(5) P. R. Isaac and S. M. Kalegh, *Jour. Agr. Res.*, **47** (1933), 561.
(6) M. Kanda, *Tohoku-Nogyo* (in Japanese), **4** (1950), 146.
(7) T. Kitagawa, *Tables of Poisson Distribution* (in Japanese), Tokyo (1951).
(8) J. Neyman, *Ann. Math. Stat.*, **10** (1939), 35.
(9) S. Okamoto, *Oyo-Kontyu* (in Japanese), **5** (1949), 70.
(10) E. J. Keck and J. A. Kuney, *Agron. Jour.*, **43** (1951), 17.
(11) "Student", *Biometrika*, **5** (1907), 351.
(12) T. Uchida et. al., *Oyo-Kontyu* (in Japanese), **7** (1951), 89.
(13) H. Yuasa and T. Koyama, *Agr. and Hort.* (in Japanese), **14** (1939), 767.

A Newly Devised Method for Soil Colloidal Fractionation

The First Report — Examination of the Method in Which Thermal Diffusion Is Applied*

Akio Fujiwara and Matsubei Wakô

(Received January 16, 1952)

I. Introduction

Needless to say that soil colloidal substances are one of the most important objects of researches in the field of soil science, but these colloidal materials are not all of them of the same kind. They are organic matters or inorganic, compounds or mixtures of the both, and are thought to be composed of groups of particles different in size, shape, surface properties and so on.

The trials of fractionating these colloidal materials into their component parts have been attempted and failed. We, who have thought of the soil scientific importance of clarifying the nature of each component of various soil colloidal materials, made attempts to separate each of them by devising some effective method.

The way of separating soil colloidal materials has mainly been: on the supposition that the material is ball-shaped it is dispersed into liquid phase having equal temperature, then by gravity or centrifugal force comparatively heavier things are put apart first. Calculation of the size of these particles has been according to Stokes' Law, which is

$$v = \frac{2gr^2(d-d')}{9\eta} \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (1)$$

where

v: subside velocity
r: radius of soil particle
d: density of soil particle

* The 69th report of the Institute for Agricultural Research, Tohoku University (1952).

d' : density of dispersion medium (water)
η : viscosity constant of the same

As is known by the equation (1), the smaller the particle is, the slower becomes its subside velocity and the more difficult its separation accordingly. Again, the almost known fact today from various points of study is that most of the soil colloidal materials are not globular. If particles are not globular they show stronger resistence in liquid and slower velocity of subsidence and consequently the separation must become more difficult. Actually in the colloidal substances which we had separated from Red Onji by the subsidence method a mineral of hexagonal plate was unexceptionally found mingles. The error in the size of a particle calculated by the equation (1) must be bigger in proportion as the particle is smaller and its shape deviates farther from globular shape.

Physical and chemical characters peculiar to soil are though to be found in soil colloidal substances, especially of shorter than 0.002 mm in diameter. In other words, as is pointed out by G. W. Robinson[1] and others, soil particles can generally be regarded as fragments of rock when they have a diameter larger than 0.02 mm. Therefore, it may safely be said that soil colloidal materials usually mean particles whose diameter is less than 0.002 mm. It is evident from various experiments that these soil colloidal materials are not of the same kind. For instance, clay minerals in colloidal matters have been identified in great numbers and the report has been numerous that there are several minerals mingled in them. This can be imagined from the result of chemical analyses also. When we think of the fundamental structure of a soil colloidal particle, it is convenient to employ the SiO_2/Al_2O_3 ratio, but the value has not been in whole number in many experimental results. There are, either, hardly any cases in which Shioiri[2] and Kawamura[3] obtained the integral value in this ratio.

As to this question it is left unsolved whether these soil colloidal materials are substances not showing essentially the integral value of SiO_2/Al_2O_3 ratio, or mixtures of substances showing simple integral value, or they are in the state of molecular association. From the soil scientific point of view the combination of organic substance and inorganic soil colloidal substance is of extremely great significance. Such a researcher as Tjulin[4] has built up a hypothesis, but his study has not gone any farther than the separation of each group composing so-called organomineral complex. The separation of combined things from the contrary has not been materialized as yet.

If the method is only according to Stokes' Law the difficulty in separating each component of the soil colloidal materials of various kinds will never be removed for ever. In other words application of Stokes' Law is only to make the error bigger and the separation more difficult as the particle is smaller. In order to separate each soil colloidal material the method to be taken for the

purpose must be otherwise than has hitherto been taken. Some such principle as is based on the very difference in individual properties of soil colloidal materials must be adopted. We considered the cataphoresis method by Tiselius,[5] but finding some difficult points in its application for siol colloidal materials abandoned it. Some other ways were brought into our minds, but we, here, tried to apply the thermaldiffusion coefficient which had been applied to the separation of isotopes. Following is our result of examination on this method.

II. Thermal diffusion and its application

When mixed gas or liquid has not universally equal temperature and accordingly there is gradient in density one component places itself in the side of higher temperature, while the other in the side of lower temperature generally. We call this phenomenon thermaldiffusion. This was discovered as early as 1856 by Ludwig and 1879 by Soret in solution. Afterwards Enskog and Chapman discovered the phenomenon in gases during their studies of the Kinetic theory of gases. In consequence various experiments have been conducted to clear the state of gasic molecule. One[6] of the authors tried experiments on this, measuring the thermaldiffusion coefficient. In application fields the most famous is Clusius-Dickel's[8] method, who succeeded with very simple apparatus in separation of isotopes which had been very difficult by any other method.

Separation of $H^{35}Cl$ from $H^{37}Cl$ and of ^{20}Ne from ^{22}Ne was realized to the purity of 99.5% and almost 100% respectively. Zinc isotopes in the solution of zinc sulphate and tiophen in benzene were successfully separated, separation of the latter having been chemically difficult.

As for the colloidal substances the first report seemed to be issued by Hirota[7] who confirmed the presence of this phenomenon though qualitatively. Later Kimura and Hirota[7] only tried theoretical examination based on the result of their experiments as to gelatine, cane sugar, glycerine etc. There are other records by Wessels[9] and Hartley-Gosch[10] who also observed this phenomenon.

Wereide,[11] Chapman[12] and Wirtz[13] made theoretical studies and proposed several formulae. These formulae, however, do not always agree with the results of Kimura and Hirota's experimental investigation mentioned above. Taking some of these theoretical equations we will examine the possibility of fractionation of soil colloidal materials. These laws of thermal diffusion in colloidal solutions have been introduced from those in mixed solutions. When there is density gradient present in a solution of equal temperature, movement of the solute, or diffusion, occurs. This is the ordinary phenomenon of diffusion Fick's law governs. Here the following formula stands:

$$f = -D\frac{dn}{dx}$$

where

f: amount moved in a fixed time
$\frac{dn}{dx}$: density gradient
D: diffusion constant

Similarly if temperature gradient is given to a solution of equal temperature movement of solute occurs, which may be presumed to be approximately proportional to the following equation

$$f' = -D'n\frac{dT}{dx}$$

in which

f': amount moved in a fixed time
n: density of solute
$\frac{dT}{dx}$: temperature gradient
D': thermaldiffusion constant

These two diffusions, after enough time, become proportional, arriving at the stationary state. In this relation we have

$$f = -f'$$

then

$$-D\frac{dn}{dx} = D'n\frac{dT}{dx} \text{ or } \frac{dlnn}{dx} = -\frac{D'}{D}$$

As to solutions D'/D is usually what is called Soret coefficient. Generally in case D'/D is bigger, density gradient caused by temperature gradient becomes bigger and the separation of mixed substances grows easier. In this equation D', or thermaldiffsuion constant, is unknown, and is theoretically calculated according to the kinetic theory of gases:

i) according to Wereide,[11] if solute molecule > solvent molecule

$$\frac{D'}{D} = -\frac{1}{2T} + \frac{1}{2}\frac{dlnD}{dT} \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (2)$$

ii) Chapman,[12] who discussed the distribution of colloidal particles in general stationary system including non-isothermal system, established the following formula:

$$D' = -\frac{dD}{dT} - \frac{\Delta mg}{T}\frac{D}{T} \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (3)$$

in which Δm means the mass difference between solute particle and solvent particle of the same volume.

iii) Wirtz[13] considers from the liquid-dynamic point of view

$$D' = \frac{f}{9}\frac{\pi r^3 Cv}{\mu} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (4)$$

where

Cv : specific heat of solution
r : radius of solvent particle
f : form factor, which is 1 when soloute is of elastic sphere
μ : viscosity constant

In the equations (2), (3) and (4), size of particle, difference in masses, form of the solute are the dominating factors. Especially, in (4) it is remarkable that form is counted in as a factor, which is not thought as such in Stokes' Law. This form factor is a figure determined by the physical properties fo individual particles.

Further in (3) it passes as a commonsense knowledge concerning ordinary diffusion constant that usually the smaller a particle is, the bigger is diffusion constant. Therefore it is thought that the possibility of separation is greater in proportion as the particle is smaller. With reference to this point Stokes' Law takes the opposite stand, telling that when the particle is smaller the separation is more difficult.

III. Separation of soil colloidal materials and application of thermal diffusion

As has been said above, the separation of soil colloidal materials by making application of the phenomenon of thermaldiffusion is thought to have some realizable possibilities. Here there are decidedly different factors in principle from those in Stokes' Law.

However, most of the soil colloidal materials are in micelle state, and so it would be a little unreasonable to presume such a one as a single colloidal particle. But supposing the electric charge exercise but slight influence and if only the size and shape are taken into consideration, there are remarkable differences found between particles. These differences, when applied to the above theoretical equations (2), (3) and (4), make the possibility of separation of some of soil colloidal substances inferable.

For instance, W. Laatsch[14] says that Montmorillonite ($Al_2O_3 4SiO_2 H_2O$) has 8.6-20Å of inter-stratal intervals and Kaolinite ($Al_2O_3 2SiO_2 2H_2O$) 2.8Å.

This means the difference of Δm in the above equation (3) and accordingly the separation seems possible. Again, if thermal diffusion constant is given by the equation (4), it is proportional to fand r^3, as it must be thought that there is little change as to Cv and μ. Here, too, we may expect the separatibility.

According to G. W. Robinson[1] the finest particles are thought to be in the neighborhood of 0.00006mm, in their size, of such a fraction the sedimentation velocity being calculated to be 10^{-7} cm/sec. by using Stokes' Law. These particles are very difficult to separate under gravity or centrifugal force. As to this respect it is thought that the method in which thermal diffusion is made use of has a greater rate of separation according as the absolute size of a particle becomes smaller.

However, as has been pointed out by Hirota,[15] there may be observed abnormal phenomena of separation in some mixed solutions, so it would be too much to conclude that thermal diffusion is available in every case for fractionation of soil colloidal materials.

IV. Separating apparatus

Thermal diffusion coefficient of colloidal materials has been thought considerably small, but the value has hardly been asked for experimentally. In the case of solution, though ordinary diffusion coefficient is nearly 10^{-5}, that of thermal diffusion is about 10^{-8}. Thus thermal diffusion power is very small but when Clusius-Dickel utilized the effects of thermal diffusion and of gravity together, direct application of the former came to be made to the separation of materials. We also made an apparatus modelled after theirs. Theoretical consideration for this type of separating apparatus has been given by Debye,[16] who says, when there is no sample reservoir, suppose θ be time requierd for movement to reach stationary state, then

$$\theta = \frac{h^2}{\pi^2 D} \cdot \frac{1}{1 + \frac{q^2}{7680}}$$

in which

h : length of vessel's wall with difference of temperatures
D : ordinary diffusion coefficient
β : expansion coefficient of solution
q : $\frac{\beta g \rho \tau}{a \mu D} a^3$
g : gravity

ρ : density of solution
τ : difference of temperatures between walls
a : distance between walls with difference of temperatures
μ : viscosity of solution

If the ratio of density of solution at its upper and lower parts be n'/n, the above relation would be

$$ln \frac{n'}{n} = \frac{\frac{q}{120}}{1 + \frac{q^2}{10080}} \frac{D'}{D} T \frac{h}{a}$$

D' : thermal diffusion coefficient

in case $q \gg 100$

$$\theta = \frac{h^2}{\pi D} \frac{7680}{q^2} \qquad ln \frac{n'}{n} = \frac{504 \mu h}{\beta g \rho a^4} D'$$

From these equations it may be concluded that the shorter a is and the longer h is, the bigger becomes n'/n and the longer θ. According to Debye's calcutation, 0.1mm is the convenient distance between walls. Practically it is difficult to make a thermal separation tube of less than 1 mm. of wall-distance with a common glass-tube. So is it to make the tube elongated.

Hirota[15] carried out his experiments with a tube of 1.5 mm in wall-distance and 94 cm in length of the part. He says this is convenient because of the short time to reach the stationary state, though the separation rate is low. We made for our experiments such an apparatus as is illustrated in Figure 1.

First we made a tube A which has 1.09 mm of wall-distance a where there is difference of temperature, 275 mm of length of the part h, and reservoirs of 25 cc of capacity. Trials with oxalic acid solution made us sure that even this apparatus would be available for measurement of thermal diffusion. Next we made a tube B of which a is 0.77 mm and h 200 mm. This was superior in separation rate. The figure a, however, was in both cases taken as average, and so not necessarily accurate.

In Figure 1 the outermost glass tube is a cooler, of which cold water is introduced from the bottom holes and let out of the issues at the top. The glass tube in the center serves as a wall of the high-temperatured part and inside it desired temperature is obtained by heating the nichrome wire. In our experiments as the difference in temperature of this part and cold water was regarded as the difference of temperature (ΔT), this ΔT is not strictly accurate and constant. This central tube has, at the top and bottom each, three projecting points of glass with which it touches the cylindrical tube in the middle. Between

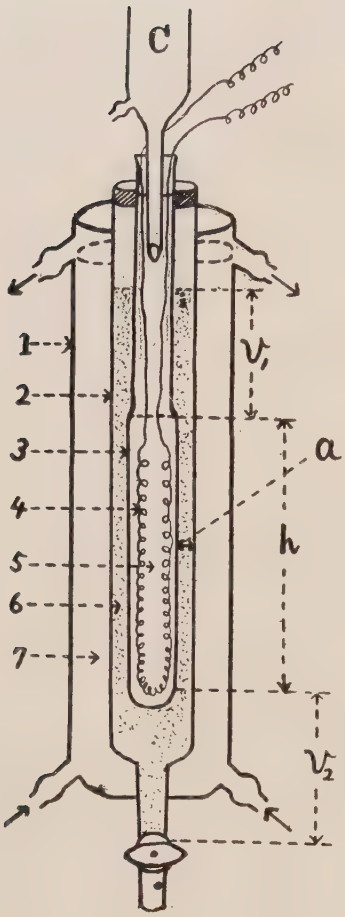


Fig. 1.

these two tubes is sample filled full. The space made by the part of the inner tube where the diameter is biggest and the middle tube is regarded as walldistance with difference of temperature. By the way cold water was made to be at such a temperature as its difference was kept less than 0.5° at the entrance and the outlet. Inside the central glass tube where the temperature is high nichrome wire was so placed that is was close at the lower and rough at the upper part and the thermal difference there could be kept at about ±1.5°.

1. glass tube of low temperature part.
2. sample holder.
3. glass tube of high temperature part.
4. heater.
5. hot water.
6. sample.
7. cold water.

C. condencer.
a. distance of wall, defference in temperature.
b. length of wall, defference in temperature.
v_1 uper reservoir.
v_2 lower reservoir.

V. Experimental

By employing the apparatus explained in the previous chapter 4 we measured first the density of oxalic acid solution at its upper and lower parts and obtained the following result (Table 1).

It is evident that with such a simple apparatus measurement of thermal diffusion can be made. The separation ratio is known to be higher when tube B is used. Owing to the unsatisfactory equipment of electric source the high temperatured part was a little unstable and so continuous working for a long time was met with difficulty. At the biginning of working bubbles attached to the glass wall of the high temperatured part, so it was necessary to remove them.

Table 1. Thermal separation ratio of oxalic acid.

Tube	Difference of temperature ΔT °C	Time repuired for treatment	Ratio of separation $\left(\frac{\text{lower density}}{\text{upper density}}\right)$
A	80	1	1.051
〃	〃	2	1.077
〃	〃	3	1.111
〃	〃	5	1.135
〃	〃	7	1.134
B	〃	1	1.010
〃	〃	6	1.240
〃	〃	8	1.290

Remarks: i) 0.2N of oxalic acid solution was used.
ii) Ratio of separation is the average of 3-5 tests.

Next measurement was carried out as to a few soil colloidal substances. The result is given in Table 2. In this experiment samples were evaporated on the water bath and then dried up in the air bath at the temperature of 110° C, then the weight was compared. Samples used were all fresh soils, which had been dispersed in distilled water and placed in the room of constant temperature.

Table 2. Comparison of density by weight.

Soil	Diameter of particle by Stokes' calculation	Difference of temperature °C	Time required for treatment	Density in upper part mg/200cc	Density in lower part mg/200cc	Not treated mg/200cc
Abukuma alluvial soil	0.1μ>	80°	6	26.4	27.2	26.6
Yamai sub-soil	0.2μ>	〃	6	35.6	38.4	37.4
Semi clay	0.2μ>	〃	3	22.0	23.6	22.5
〃	〃	0°	15	22.2	21.7	22.5

Remarks: Tube A was used in all cases. Weighing was conducted after the sample in the desiccator had been placed in room temprature for half an hour.

Comparison by weight requires considerabls amount of samples and moreover of adsorbing water. The following Table 3 is the tabulated results of measurement of the separation ratios by means of the nephelometer.

Because the colloidal solutions were too dense, or heat worked, or there might be other causes, solidification occurred in 2 and 3, resulting in anomalous separation. Samples 4 and 5 also produced solidified things. In 6 and 7 solidification was not seen, but the samples were too dilute for the result to be thought exact.

Some figures in the above Tables 2 and 3 do not show distinct causes of separation. However, the different densities which colloidal materials have at the upper and lower parts from those caused by only ordinary diffusion and gravity

Table 3. Separation ratio by thermal diffusion.

Scil	Difference of temperature	Tube used	Time required for treatment	Separation ratio
1. *Yamai* sub-soil	0	B	15	1.010
2. 〃	80	〃	9	1.566
3. 〃	〃	A	8	1.471
4. *Semi* clay	0	A	15	1.000
5. 〃	80°	〃	8	1.065
6. *Abukuma* alluvial soil	0	B	15	1.000
7. 〃	80°	〃	7	1.020

Remarks: i) Samples 1, 2, and 3 were a little too dense; plainly anomalous separation.
ii) Samples were less than 1 μ, a little bigger for colloidal materials.
iii) Nephelometer used was of photoelectric type.

are thought to be effected by the work of thermal diffusion. But the meanings the figures have are very complicated. Solidification, dehydration, changes by heat must be considered, or considerably numerous kinds of colloidal substances are thought to be contained in the samples. Another investigation we made revealed the presence of innumerable kinds of clay minerals in the samples 6 and 7. Separation ratios of these have very complicated meanings and so we[17] conducted experiments on thermal separation with minerals of which properties are somewhat known to us. The results shown in Plate I, Photos. 1 and 2 were obtained by such experiments on mixed colloidal solution of minerals of Kaolinite group and Halloysite group. According to these, which were photographed with the electron microscope, the proportion of the minerals of Halloysite group to those of Kaolinite one is bigger at the lower part. This shows the possibility of separation between Kaolinite group minerals and Hallysite group ones.

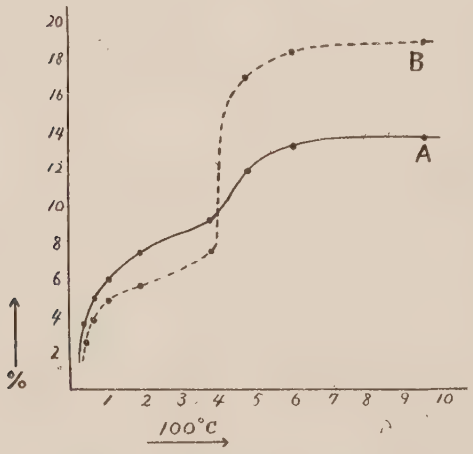


Fig. 2

By the way minerals of Kaolinite group were from Takatama Gold Mine, Saitama-ken, and those of Haloysite group from Shiraiwa-mura, Fukushimaken. Both were dispersed in distilled water, then worked by the centrifuge for 15 minutes at a speed of 3000 revolu-

tions a minute. Of these the upper solution was employed in our experiment. Tubes were of *B* type. The high- and lowtemperatured parts kept 75°C±2°C and 15°C±0.5°C respectively; ΔT, 60°C and the time for working, 10 hours.

Remarks: Materials of platy type are minerals of Kaolinite group from Takatama Gold Mine and those of rod type belong to Halloysite group, coming from Shiraiwa-mura. SiO_2/Al_2O_3 is 2·27 and 2.16, SiO_2/R_2O_3 2.012 and 2.10, dehydration curves A and B in the following graph, respectively in the cases of the former and the latter.

VI. Discussion

From the above results of our experiments it is evident that when thermal fractionation is carried out with Clusius-Dickel tube soil colloidal materials, too, present density gradient at their upper and lower parts somewhat different from that caused only under gravity. This shows that the fractionation was realized to some degree by the forces of thermal diffusion and gravity worked together, which can also be confirmed by Table 2 in which weight is compared and Table 3 showing the result by employing the nephelometer. The bigger density ratio in the case of tube *B* than when tube *A* is used, shown in Table 2, may be regarded as in accordance with the laws of thermal separation. On the other hand, in Table 3 particles assuming coagulation state at the lower part was thought to be abnormal separation, as pointed out by Hirota.[15] Further, in Plate I, Photos. 1 and 2 the electron microscope betrayed the coagulation of most particles at the bottom, though not detected macroscopically. However, most of these colloidal particles are not dispersed singly either when they do not undergo thermal treatment, which Plate II, Photos. 3 and 4 demonstrate. Therefore, it is thought that the phenomenon in the case of Plate I, Photo. 2 can not easily be called mere abnormal fractionation. Again, Halloysite is said to be converted into Kaolinite at the temperature of 100°C or thereabouts, and colloidal materials are changeable by heating, so experiments must be tried at lower temperatures, if possible.

Samples placed under the electron microscope to be photographed are all of them particles with less than 0.2μ of diameter according to Stokes' Law's calculation, but it is known by the pictures that among them are present a considerable number of things more than 1μ, far bigger than the calculated figures. In other words even with a size of such degree figures obtained through the electron microscope deviate very far from the application of Stokes' Law. This Marshall[18] has pointed out.

The apparatus employed was in some degree unsatisfactory, not available for long experiments.

In the point of regulation of temperatures we could not make experiments at satisfactorily low temperatures. Therefore, it is open to question that these

experimental results are put to direct use as a basis of calculation to infer thermal diffusion constant. This must be left for our later investigations.

As has been stated in the above chapter 2, a big particle may cause small thermal diffusion coefficient. And so we must further our experiments with regard to samples containing finer particles.

Anyhow, by applying the effects of thermal diffusion a hopeful light has been thrown before the way to the realization of fractionation of variuos sorts of soil colloidal materials or clay minerals, of which we have hardly had any means.

VII. Conclusion

The foregoing results of our experiments may be summarized : the apparatus was not necessarily thought satisfactory because it was rather for use in preliminary experiments, but it was ascertained that in soil colloidal solution too thermal diffusion is observed to act and fractionation takes place to some extent according to Clusius-Dickel's method. However, the results are qualitative and do not seem to give us a basis for accurate calculation. It is necessary to improve this apparatus so that we can obtain reliable, precise results. There are high hopes of this realization.

In concluding this paper our thanks are due to Prof. Omori of this University and Mr. Shozo Ui, Shiraiwa Yozai Sha, Motomiya-machi, Fukushima-ken, for their assistance in obtaining samples and their judgment, and to Prof. T. Hibi and Mr. S. Takahashi, both of the Research Institute for Scientific Instrument, this University, for their technical assistance in taking photographs with the electron microscope.

Literature

(1) G. W. Robinson, *Soils*, (1936) 16.
(2) M. Shioiri, Proc. Japan Sci. Soc (Nippon Gakujitsu Kyokai Hokoku) **10** (1935), 694.
(3) K. Kawamura, S. Funabiki, J. Sci. Soil. Manure. Japan, **8** (1934), 406 ; **10** (1936), 281.
(4) E. Tjulin, Soil. Sci, **45** (1938), 343.
(5) A. Tiselius, Kolloid. Z., **85** (1938), 129.
(6) K. Kitagawa, M. Wako, J. Chem. Soc. Japan, **62** (1942), 100.
(7) O. Kimura, G. Hirota, J. Chem. Soc. Japan, **65** (1945), 118.
(8) Clusius, Dickel, Naturwiss., **26** (1938), 546.
(9) H. Weseel Z. Physik. Chem., A, **87** (1914), 215.
(10) Hartloy, Gosch, Trans. Faraday Soc., **27** (1931), 1.
(11) R. Wereid, Ann. Physik, **2** (1914), 67.
(12) S. Chapman, Proc, Roy. Soc., **119** A, (1928), 34.
(13) K. Wirtz, Naturwiss., **27** (1939), 369.
(14) W. Laatsch, *Acker=und Waldböden*, (1938), 43.
(15) G. Hirota, J. Chem. Soc. Japan, **62** (1941), 480.
(16) S. Debye, Ann. Physik, **36** (1939), 284.
(17) A. Fujiwara, M. Wako, Bull. Inst. Agr. Res. Tohoku Univ. (in Japanese), **3** (1952).
(18) C. E. Marsholl, *The Collaid Chemistry of Silicate Minerals*. (1949), 65.

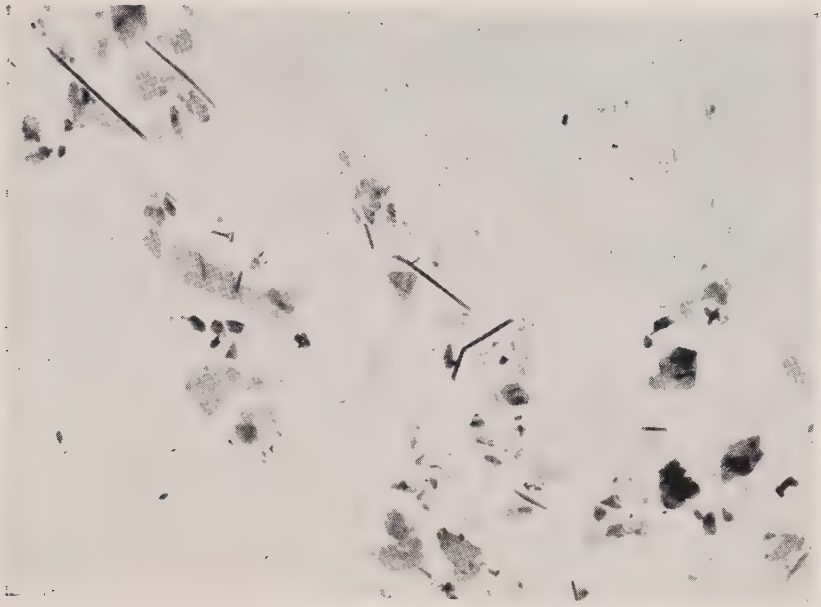


Photo. 1. Colloidal materials in the upper reservoir 10000 magnifications.

Photo. 2. Colloidal materials in the lower reservoir 10000 magnifications.

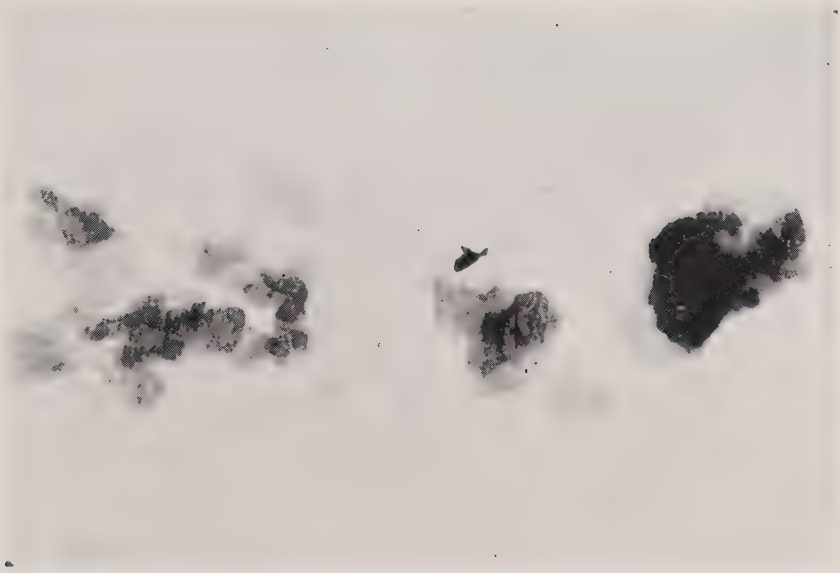


Photo 3. Kaolin from Takatama.
Dispersed in H_2O ; 20,000 magnifications.

Photo 4. Halloysite from Shiraiwa.
Dispersed in H_2O ; 20,000 magnifications.

Results of Electron Microscopical Examinations of Clay Minerals in Japanese Soils*

Akio FUJIWARA and Matsubei WAKÔ

(Received January 20, 1952)

I. Introduction

Methods of researches on soil colloidal materials and clay minerals are numerous. Among then the electron microscope method has been successfully applied to morphological identification of most of the clay minerals.

In examining colloidal materials contained in bad soils of volcanic ash loam in Japan we followed the method by the electron microscope. Part of the results shall be given here.

As to the kinds and shapes of clay minerals, Marshall[1] describes of Dickite, Kaolinite, Halloysite, Endellit, Illite, Beidellite, Nontronite, Hectrite, Montmorillonite, Sauconite, Attapulgite, Sepiolite etc., but comparatively few kinds have been proved their identify in Japanese soils.

What kinds of clay minerals compose Japanese soil colloid? Most of them are Halloysite, says Kawamura[2], and Metahalloysite, infers Shioiri.[3] As to the clay minerals in the soil of patty rice fields, Harada[4] infers that they are Kaolinite, Illite and some other. In the studies of acid earth white Sasaki[5] insisted the the upper horizons were composed by Endellite and Halloysite, while the lower ones chiefly Endellite. Kuramoto[6] et al reported that the top soil was Metahalloysite and the sub soil Montmorillonite or Crystoballite in addition to it.

We fractionated volcanic ash loam and for comparison clay minerals in various sorts of soils and took their photographs with the electron microscope for analysis.

II. Experimental

Most of the samples used are fresh soil, only a few air dry soil. First H_2O was added to the sample, which then was slightly broken and the organic things floating in the H_2O removed. Next H_2O or 0.01% NaOH, or in the case of allitic soil 0.01% HCl was added, and then the soil was ground into powder with a brush

* The 70th report of the Institute for Agricultural Research, Tohoku University. (1952).

to disperse. The supernatant was put to use. Table I is the tabulation of these samples as arranged according to their kinds and ways of treatment.

The electron microscope we used is the one installed in Prof. Hibi's laboratory, Research Institute of Scientific Measurements, this University, of magnetic field HU-6 type, accelerating potential 50 kV made by Hitachi Seisakusho.

III. Shapes of soil colloidal materials

1. Acid Earth H_2

Acid Earth H_1, G_1, and H_2 we used for our experiments and been all gathered by us, which meet the conditions described by Sasaki [5][7]. Therefore, they were not the same things in the strict sense of the word as what Sasaki calls Acid Earth H_1, G_1, or H_2. However, in the order of profile, soil color and the sense of touch those samples are perfectly in accord with the described conditions.

The most noteworthy in Photo 1a is the crystalline semi-sexangular matter, thin and beautiful. This is very thin, allowing particles under it to be clearly observed. On the surface of it there are many little black spots seeming something adsorbed.

This resembles Dickite,[8] of Marshall in shape, being as thick as Kaolinite.[9] Among others are things of Montmorillonite Fulffy type.[10] But most of the matters have irregular shape near Beidellite.[11] Rod-like character and notches at the ends, characteristics of Halloysite and Endellite,[12] are not seen at all.

Montmorillonite is said to present various shapes, and so from this picture its presence can not be determined. Anywho it is clear that there is no Halloysite of rod-like type in it.

Photo 1b resembles Photo 1a, but shows a type more like Montmorillonite Platy type.[13] Hexagonal platy things are seen in somewhat irregularly crushed state.

2. Acid Earth H_1

In Photo 2a are found considerable numbers of matters which show rod-like character and notches at the ends, characteristics of Halloysite and Endellite. There is also seen Beidellite-like part.

Crystalline hexagonal platy things seen above in Photos 1a and 1b are seen in Phot 2b, but here their tops are in such a state as if they were weathered. The size is 3μ or so. What they are can not be told. From this picture it is known that this substance has a remarkable cleavage and on its surface is something adsorbed.

3. Acid Earth G_2

Photo 3 reveals that the greater part of the clay minerals are platy substances having a type resembling Montmorillonite Fluffy type. Rod-like type of Halloysite is not noticeable. Notches at the ends are hardly to be seen, either. There

are rather more that are of rectangular platy type. Some part is like Nontronite.[14] But the greater part are irregular in shape. This shape makes us expect that they will turn out to be Beidellite, or Serisite.

This Acid Earth G_2 is generally thought to be acid earth white of the best guality here. This means that there are various kinds of minerals mixed in it.

4. Yamai top soil

Shoiri and others remark that colloidal substance contained in this soil is Metahalloysite. Rod-shaped material with notches at the ends is distinctly observed, though small notches at the ends is distinctly observed, though small in numbers, by means of Photo 4. But the greater part is of poorly defined particle shape or size. $SiO_2 : Al_2O_3$ ratio being 3.48 gives ground for thinking that Metahalloysite does not occupy the greater part, even if it is present. It is thought that Photo 4 presents the actual state of this.

5. Yamai sub soil

It has been concluded by Shioiri and others that colloidal substance in this soil is Montmorillonite. In Photo 5 few of rod-like materials are to be seen, out nothing with notches at the ends. On the left side of the upper part there are seen long platy materials. On the left of the middle are many thin platy things of irregular shape. This shape is thought to belong to Nontronite or Beidellite. This may also be considered Montmorillonite of platy type. Judgment of this part can not easily be made with these samples alone. Anyhow it is certain that there exists not a simple matter, but various kinds of substances mixed. According to the researches by Shioiri et al it is Montmorillonite and so those seen in the photo may be regarded, the greater part of them, as a shape of Montomorillonite. But there are seen some mixtures of clearly rod-shaped material and Nontronite-like material. The results described in the above-mentioned report of Shioiri and others seem to have deviated a little way from the characters of Montmorillonite.

6. Kurosawajiri sub soil

The colloidal material found in the soil is the same as Shioiri et al regarded as Halloysite in other soils.

Rod-like type can be seen in neither Photo 6a nor Photo 6b. Numerous particles of very fine size are known to be present in Photo 6a. These particles are so small as 10mμ in diameter. Though not observed in print, it is revealed through the plate that this particle is a congregation of several smaller particles. In Photo 6a besides these are seen filmy materials the circumferrence of which is dim and obscure. In Photo 6b filmy materials and shapeless substance are seen. These materials which are found in Photos 6a and 6b are inferred to be fragments of Allophane. The extraordinary shape in Photo 6a is thought be to caused by their remaining for a long while in water. On the thin pellicles in Photo 6b there

attach throughout the surface particles much finer than those seen in Photo 6a which can not be made distinctly shown in print.

What these are can not be told. They may have been caused by electron application.

But it has been known after examination that the intensity of electron illumination is independent of this phenomenon. There are some materials which suffer changes according as the intensity of electron illumination varies. Of which we shall give examples later on. Particles except filmy substance in Photo 6b are not of platy type. On the right side of the upper part there are a few particles as small as those in Photo 6a.

7. Mikatagahara top soil

This is a deluvial soil of non-volcanic ash nature, weathered to an advanced degree. If the process of weathering takes such a course : rocks — Montmorillonite — Metahalloysite — Halloysite — Allophane, this sample is inferred to be in the latter course, Halloysite — Allophane.

Photo 7a represents no characteristic rod-like type. In Photo 7b we can observe materials of Allophane-like films. On the surface of the film there can be

Table

photo No.	name of sample	mother material	$\frac{SiO_2}{Al_2O_3}$ soluble conc HCl	$\frac{Fl_2O_3}{Al_2O_3}$ soluble conc HCl
1a. 1b	Acid Earth H_2	Liparite	4.15(1)	0.04(1)
2a. 2b	Acid Earth H_1	〃	3.39(1)	0.07(1)
3	Acid Earth G_1	〃	2.61(1)	0.09(1)
4	Yamai top	Diluvial	3.48	0.20
5	Yamai sub	〃	2.96	0.22
6a	Kurosawajiri sud	Volcanic ash	2.06	0.36
6b	〃	〃	〃	〃
7a	Mikatagahara top	Diluvial	1.63	0.28
7b	〃	〃	〃	〃
8a. 8d	Hosono sub	Volcanic ash	1.21	0.21
8c	〃	〃	〃	〃
8d	〃	〃	〃	〃
9a	Abukuma top	newly tramsported	3.56(1)	0.38(1)
9b. 9c	〃	〃	〃 (1)	〃 (1)
10	Semi clay	Deluvial	2.64(1)	0.16(1)
11	Daikoku clay	Tertialy Tuff	2.71(1)	0.92(1)
12a. 12b	Kashii red soil(4)	Tertialy Liparite	1.66	—
13	Zao sub X	Volcanic ash clay	1.51(1)	0.29(1)
14a	Zao sub III	Volcanic ash sand		
14d	〃 (5)	〃		

foot note : (1) Gedroitz method, soluble in 10% HCl. (2) after 10 times the centritugal method. (4) received an offer from K. Yamanaka, Natl.

place cf sampling : 1. 2. 3. : Himegawa, Imai mura, Nishikubiki gun, Niigata ken.
4. 5 : Yamai, Yanokuchi mura, Hienuki gun, Iwate ken.
6 : Kurosawajiri, Iide mura, Waga gun, Iwate ken.
7 : Mikatagahara, Aichi ken.
8 : Hosono, Kobayashi machi, Miyazaki ken.

seen a lot of things attached, the size of which is larger than those seen in Photo 6b. And there are few platy particles seen in Photo 7a, as is the case with Photo 6b. On the right side of the lower part of Photo 7a considerable numbers of particles as fine as those seen in Photo 6a are seen. We find many types common between Photo 6 and Photo 7.

8. Hosono sub soil (Red Onji)

This soil has been introduced as Onji by Seki. Shioiri[15] infers the clay mineral in sol solution of this soil to be Allophane. He thinks this soil a typical allitic soil. Shapes of the colloidal substances contained in this soil are, as is shown in Photos 8a, 8b, 8c, and 8d, very complicated. In Photo 8a large, beautiful sextangled platy things are seen. These are thoght to be of the same kinds as observed in Photos 1a and 1b. Others are most of them shapeless materials. Photo 8b is a magnified picture of these shapeless materials. They can be classified under the following 4 kinds: (a) sexangled platy materials broken to pieces, (b) fragmentary allophane films closely resembling the semi-transparent shapeless part of Photo 6a, (c) semi-transparent curdy materials, (d) grape-clustery black materials.

1.

preparation of sample				
dispertion medium	seperation method	number of turning or time of rest		position of sampling from liquid level
H_2O	centrifuge	3000/min	15 minutes	1— 3 cm
〃	〃	〃	〃	〃
〃	〃	〃	〃	〃
0.01% NaOH	〃	〃	〃	〃
H_2O	subside		180 bays	1—10 cm
〃	〃		500 days[2]	1—30 cm
〃	centrifuge	1500/min	15 minutes	1— 2 cm
0.01% NaOH	〃	3000/min	50 minutes	〃
〃	subside		17 days	〃
0.01% HCl	〃		14 days	〃
〃	centrifuge	3000/min	50 minutes	〃
〃	subside		28 days	〃
H_2O	sudside		90 bays	1— 5 cm
〃	〃		180 days	〃
〃	〃		〃	1— 9
〃	〃		21 days	1— 2
0.01% NaOH	centrifnge	3000/min	50 minutes	〃
0.01% HCl	〃	〃	〃	〃
〃	〃	〃	〃	〃
0.01% NaOH	subside		7 days	〃

washed by H_2O. (3) 15b sample is the subsided material from the 15a by Inst. Agr. Sci. Tokyo.

9: Watari machi, Watari gun, Miyagi ken.
10: Semi, Nishioguni mura, Mogami gun, Yamagata ken.
11: Daikokuten, Mt Zao, Miyagi ken.
12: Kashii machi, Kasuya gun, Fukuoka ken.
13.14: Sugiamine, Mt Zao, Miyagi ken.

We took other photographs differently, Photo 8c makes it known that the above curdy materials are congregated fibriform materials, and Photo 8d reveals the presence of rather big spherical materials and black particles as small as those seen in Photo 6a as well as it confirms that of grape cluster-like materials.

Those soils we dealt with above are the soils containing colloidal materilas whose properties have already been more or less studied.

Now we intend to tell about other soils which have some interesting relations to the above in respect of their mother rock or SiO_2/Al_2O_3 ratio. They are 9-14 in Table.

9. Abukuma top soil (Newly transported soil)

In this soil are found many kinds of clay minerals — Halloysite and Endellite of rod-like type, Kaolinite inferred, mineral of Nontronite type, Dickite inferred and many other with irregular shapes.

Photo 9a shows their general figure, Photo 9b pentagonal platy form which seems to be Dickite. This corresponds with the Dickite of Marshall in being irregularly pentagonal, but the former bears on its surface speckles, dark and light. These speckles were observed to suffer slight changes with electron illuminated. Experimentally speaking, at first when this substance was placed under the electron microscope light and shade were not clearly distinguished. But when we raised the intensity of illumination by electron so as to get a better observation clear speckles were formed as if they were condensed.

Light and shade in Photo 9c were produced in course of microscopical study of what had been homogeneously semi-transparent. In case of Photo 9b it seems as if there were something attaching, but this is not the case with Photo 9c.

10. Semi clay

This clay is the lowest part of deluvial soil and the upper part of Tertiary tuff, Strictly speaking, it cannot be affirmed to which it belongs. In Photo 10 the types Halloysite and Endellite are distinctly observed.

11. Daikoku clay

This is reddish yellow clay, weathered pure Tertiary tuff. Analysis showed that this soil contained a great deal of iron. We find typical Halloysite and Endellite in Photo 11, besides which there are seen shapeless thin platy things and small spherical things. The former seem to be a form of Nontronite.

12. Kashii red soil

The SiO_2/Al_2O_3 ratio of this soil is low. There are many of rod-like type in it, which are thought to be Halloysite and Endellite. On the other hand in Photo 12b are seen matters of the same type as seen in Photo 2b.

13. Zao sub soil X

This soil was obtained from the Sugigamine Peak[16] of the Zao mountain ranges. The soil profil here consists of 10 horizons, to the lowest of which does

the soil belong, volcanic ash clay weathered to a considerably advanced degree. A shape seen in Photo 13 is fibriform, somewhat resembling Sepiolite,[17] not Allapulgite.[18] In the photo are seen other shapeless black things and small black dots. There is a common respect between Photo 13 and Photo 8c. This soil in also an Allitic soil and has a general property similar to that of Onji.

14. Zao sub soil III

This is from the third horizon of the above mentioned soil profile, a volcanic ash sand stratum which is thought hardly to be progressed in weathering. Photo 14a presents a material of small bent rod-like type not seen in any other samples. It cannot be told what this substance is.

We removed the supernatant of the sample of Photo 14a and to the rest added 0.01% NaOH to disperse it. From this sample Photo 14b was obtained. Only films of Allophane form are seen in it.

IV. Discussion

1. Montmorillonite

Of the samples mentioned above it is in (1) and (5) that the presence of Montmorillonite is insisted upon from the results of other experiments. The left half of Photo 1a and Photo 5 have a common form. The shape of Photo 5 is resemble to the shape of Shaw's montmorillonite.[19] From this it is possible to regard (5) as a form of montmorillonite. Further, Photo 5 and Photo 4 have a common part, and so have Photo 1 and Photo 3. Anyhow it is certain that montmorillonite does not present itself in pure form.

As montmorillonite itself is thought to take various shapes, we can not safely affirm the presence of this mineral only from photographed forms. On the other hand (5) approximates to Beidellite both in SiO_2/Al_2O_3 ratio and in from. Therefore it is needed to assume the presence of Beidellite from Samples (1) and (5).

2. Halloysite and Endellite

As to the shapes of Halloysite and Endellite Marshall refers to their rod-like character and notches at the ends. This characteristic shape is seen in all the above mentioned samples except volcanic ash loam, Acid Earth H_2 and Mikatagahara top soil. Kurosawajiri sub soil (6) and Mikatagahara top soil (7) are both regarded as Halloysite, but they have not the rod-like type. This makes it possible to assume that Halloysite does not necessarily take rod-like type. Again Acid Earth G_1 does not show itself in a distinct rod-like type, though it is in such conditions as the weathering seems to have been most advanced, while we observe many of the type in Acid Eath H_2 which has been less weathered than the above. It may be thought that rod-like type is lost as the weathering advances. Accordingly Samples (6) and (7) can be considered one form of Halloysite in which rod-like type has been completely deformed. If so, Halloysite may be present

in other volcanic ash loams — Samples (8) and (13). But whether or no these shapeless materials are Halloysite is a question for further pursuits. There being a strong suspicion there may be Allophane.

3. Hexagonal platy materials

This thin platy materials with six pretty angles that are seen in Photos 1a, 1b, 8a, 9c are thought to be one and the same mineral, coinciding with one the formal respect. Furthermore, in Photos 2b and 13b hexagonal thin platy materials, rather rounded, are seen. If the former is "angular" and the latter "round", both are inferred to be produced from a same mother substance. Acid Earth H_2 is "angular", Acid Earth H_1 "round." Seeing that H_2 is, compared with H_1, in lower degree of weathering, it seems that "angular" form has been metamorphosed to "round" form. As seen in Photos 2a and 2b, and 12a and 12b, "round" type is present, mixed with rod-like typed Halloysite.

"Angular" type is observed when there is no rod-like type. Besides in the above cases, "angular" type is seen in Hosono top soil, Zao top soil and Iwate top soil (volcanic ash loam), showing its wider range of presence. The biggest one reaches as far as 15μ. What substance is this type, is not known, there being a strong suspicion that it may be mica or other sesquioxide.

4. Weathering of volcanic ash and its products

Soil colloidal materials in the volcanic ash group have a great part of indistinct shape, as we stated above, exhibiting a striking contrast to those in the nonvolcanic ash group. From the photographed types of the former group we have the following materials common in various samples:

(a) materials that are shapeless when they are somewhat big in size. (Photos 6a, 6b, 8c and 13)
(b) Allophane filmy materials (Photos 6b and 14b)
(c) black granular materials (Photos 6a, 8c and 13)
(d) fibriform materials (Photos 8c and 13)

Further explanations shall be given about these four kinds of materials.

(a) There is a strong probability that Kurosawajiri sub soil will prove Halloysite from the results of other investigations. If so, in volcanic ash loam would universally be seen Halloysite. But there being a strong suspicion these shapeless materials may be Allophane.

(b) If these materials are Allophane, it is natural that they should be observed in Sample (7) which had been weathered to a high degree. No wonder that they are seen in non-volcanic ash loams. That they were found in comparatively new volcanic sand stratum like Zao sub soil III advances a suggestion as to the weathering process of volcanic ash loams, because this phenomenon is thought to be thus explained — those materials analysed on the upper part moved downwards and were settled there again.

(c) This material is not known clearly, but such a state as seen in Photo 6c may, when we consider dispersion condition, bear some relation to hydration. It has been pointed out above that the relation between the state of appearance like Photo 6a and electron illumination can not be neglected. If this is a soil colloidal material, a clay mineral, its size being small suggests the necessity to change the present conception of the smallest limit of clay minerals among the soil colloidal materials.

(d) As to materials with this shape there are hardly any other data for inferrence than its resembling Sepiolite. If there is Al_2O_3 in free state in volcanic ash loams, this may have some reference with it. But this is a problem left for further studies.

5. Relation between SiO_2/Al_2O_3 ratio and the type

SiO_2/Al_2O_3 ratios of Sample 2 and Sample 13 are 3.39 and 1.66 respectively, there being a remarkable difference between the two ratio figures. In spite of the difference of the figures there is a great part common in type. On the contrary in Sample 6 and Sample 12 where SiO_2/Al_2O_3 ratios are approximate the types are not of the same. This is thought to show that under such climatic conditions as in Japan it is necessary to regard mother-rock factor as very important in inferring clay minerals found in soils. Again to say, in Sample 2 and Sample 12 their mother rocks resemble each other, while in Sample 6 and Sample 12 otherwise.

6. Miscellaneous

As is seen in Photos 9a, 9b, 9c of Sample 9, a number of clay minerals are clearly observed to exist mixed in newly transported soil. In other samples, for example Photos 1, 2, 3 and 8a, the same kind of sample does not always consist of a clay mineral of the same kind. Therefore, we need to fractionate the colloids obtained from soils into various sub-groups when we examine the properties of soil colloidal materials.

Summary

To summarise the above statement, in Japan as clay minerals in soil colloidal materials Halloysite and Endellite are most prevailingly found except in volcanic ash loams though other clay minerals like Beidellite, Montmorillonite, Nontronite, Dickite etc. are seen.

The presence of hexagonal platy materials of unknown property is rather common. In the soils which have been weathered to a far advanced degree and volcanic ash loams there is Allophane present.

The colloidal matters in volcanic ash loams are many of them shapeless, which suggests that their composition is very complicated. A few common respects they have. Above all the presence of fibriform materials is worthy to be noted.

Colloidal materials obtained from one same soil are always mixtures of several types, at least several kinds of clay minerals present mixed.

Colloidal materials whose properties are unknown are numerous, especially in volcanic ash loams. They are present as mixtures and therefore it is thought necessary to fractionate them into several kinds of groups by some method, if we want to inquire into their properties.

In concluding this paper many thanks must be given to Prof. T. Hibi and Mr. Takahashi, of Research Institute of Scientific Measurements this University for their kindness shown in continuous assistance and direction in taking photographs.

Literature

(1) C. E Marshall, *The Colloid Chemistry of Silicate Minerals*, (1949), 72-82.
(2) K. Kawamura, S. Funabiki, J. Sci. Soil Manure, Japan, **10** (1936), 281.
(3) M. Shioiri, T. Fukuzawa, J. Sci. Soil Manure Japan, **22** (1951), 13.
(4) H. Harada, Lecture at Konto Branch Meeting of The Society of Soil and Manure, Dec, 2. 1951.
(5) S. Sasaki, J. Sci, Soil and Manure Japan, **22** (1951), 193.
(6) A. Kuramoto, Lecture at Kanto Branch Meeting of the Society of Soil and Manure, Dec. 2. 1951.
(7) S. Sasaki, J. Sci. Soil and Manure Japan, **22** (1951), 261.
(8) C. E. Marshall, *The Colloid Chemistry of Silicate Minerals*, (1949), 72.
(9) 〃 〃 74.
(10) 〃 〃 80.
(11) 〃 〃 76.
(12) 〃 〃 74.
(13) 〃 〃 80.
(14) 〃 〃 78.
(15) M. Shioiri, Proc. Japan Sci. Soc (Nippon Gakujitsu Kyokai Hokokn) **10** (1935). 694.
(16) M. Wako, Bull. Inst. Agr. Res. Tohoku Univ. (in Japanese), **3** (1951), 89.
(17) C. E. Marshall, *The Colloid Chemistry of Silicate Minerals*, (1949), 82.
(18) 〃 〃 81.
(19) B. T. Shaw, J. Phys. **46** (1942), 1032.

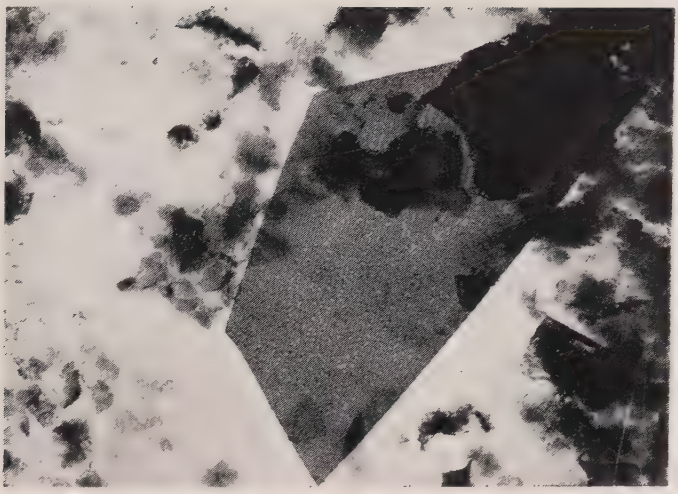


Photo. 1a
Acid Earth. H_2 ×20000

Photo. 1b
Acid Earth. H_2 ×20000

Plate II.

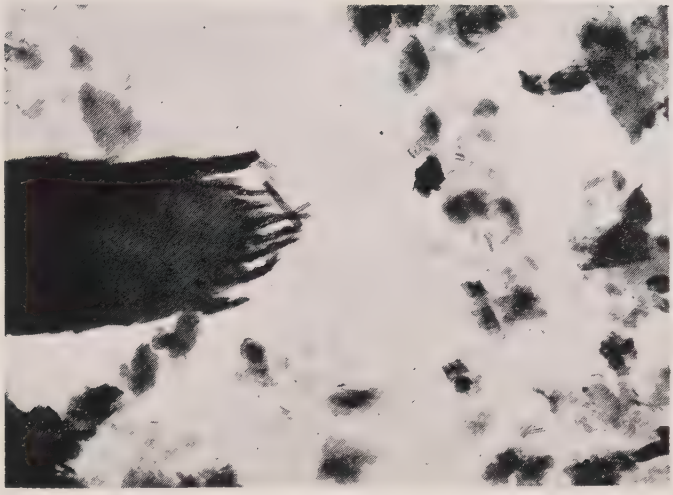


Photo. 2a
Acid Earth. H_1 ×20000

Photo. 2b
Acid Earth. H_1 ×20000

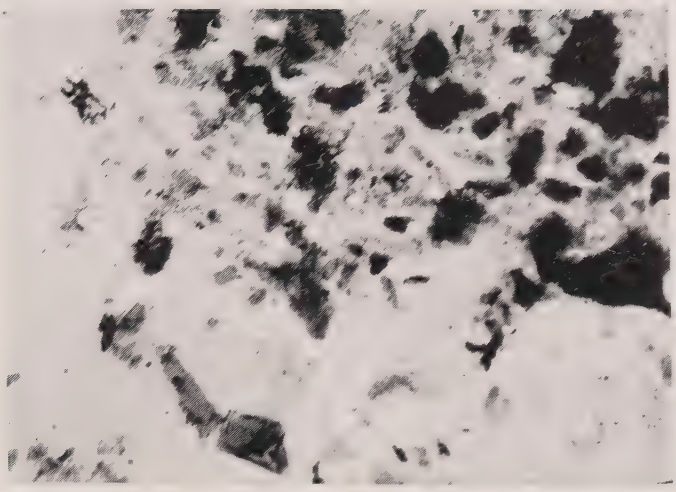


Photo. 3
Acid Earth. G_1 ×20000

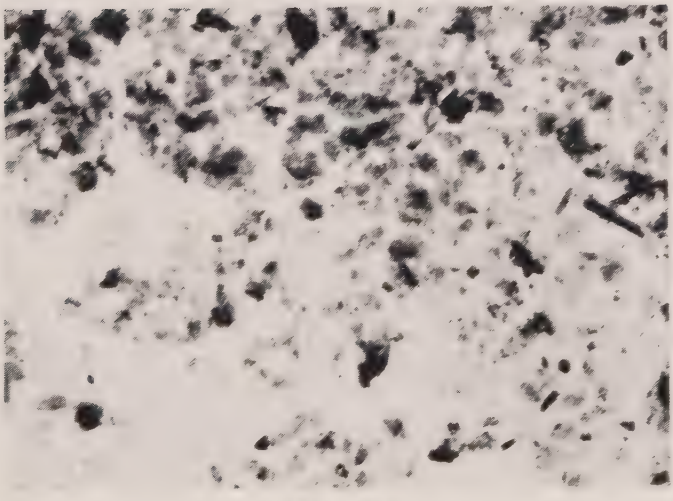


Photo. 4
Yamai top soil ×20000

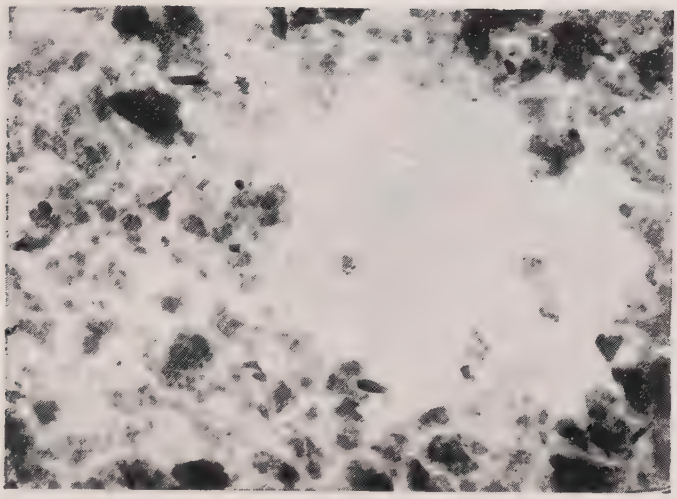


Photo. 5
Yamai sub soil ×20000

Photo. 6a
Kurosawajiri sub soil ×20000

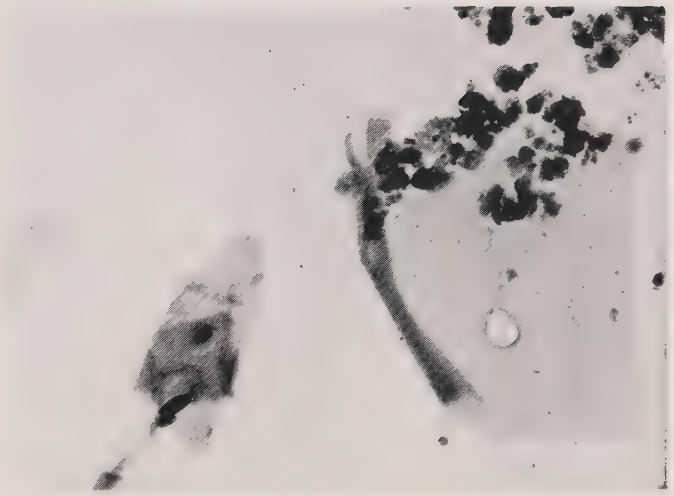


Photo. 6b
Kurosawajiri sub soil ×20000

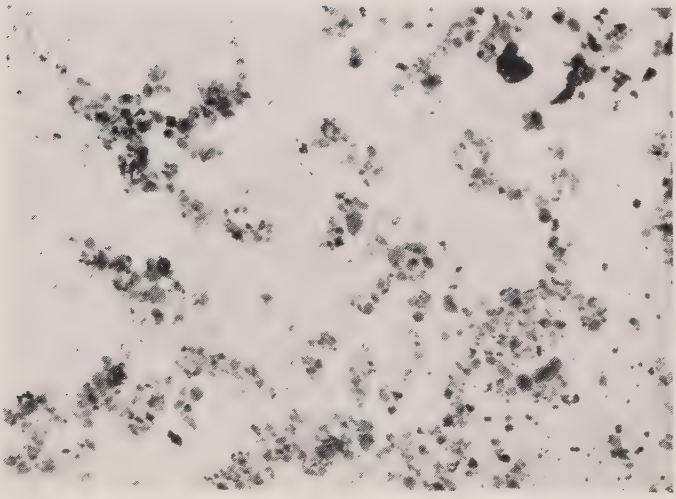


Photo. 7a
Mikatagahara top soil ×28000

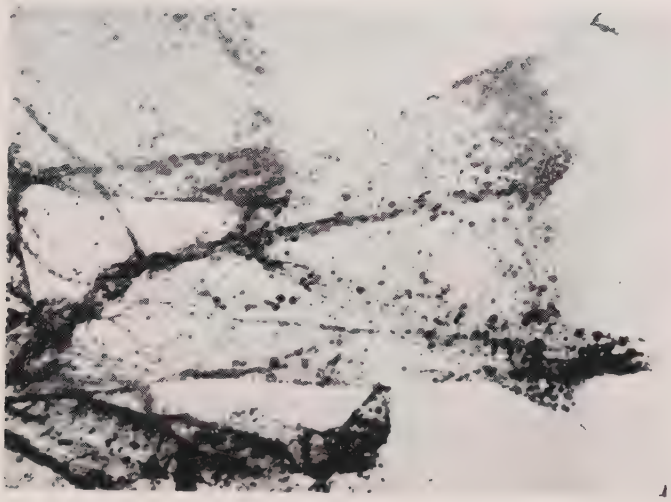


Photo. 7b
Mikatagahara top soil ×20000

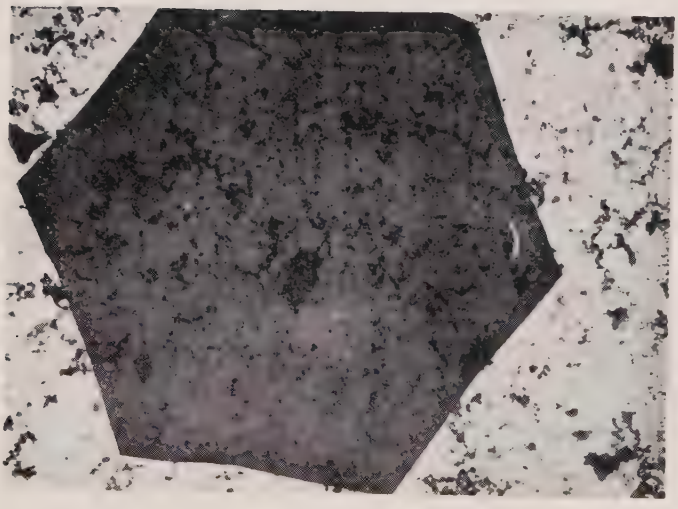


Photo. 8a
Hosono sub soil ×9000

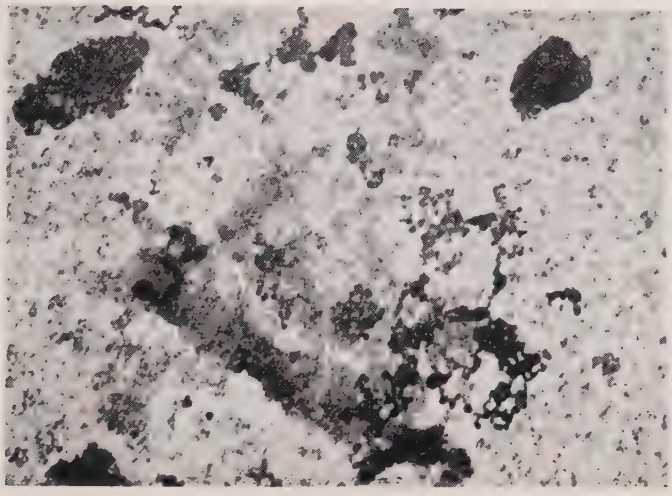


Photo. 8b
Hosono sub soil ×45000

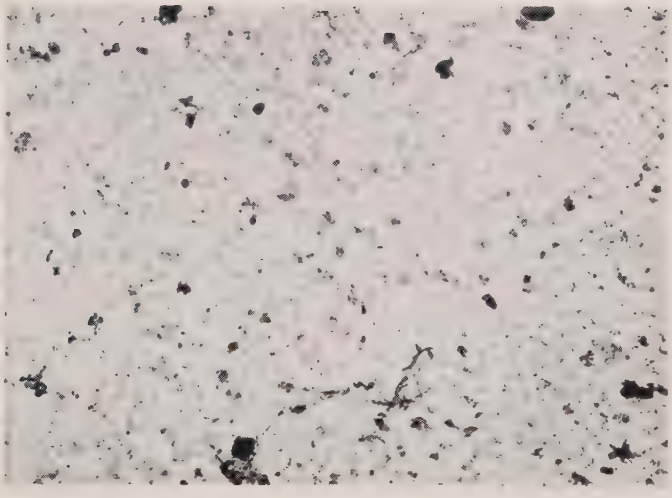


Photo. 8c
Hosono sub soil ×20000

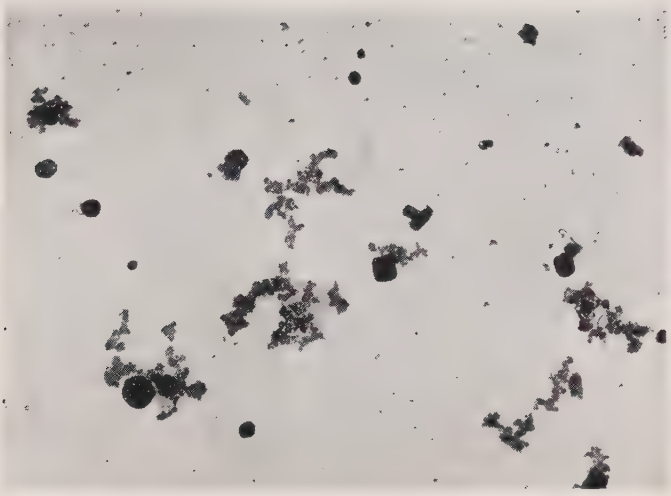


Photo. 8d
Hosono sub soil ×20000

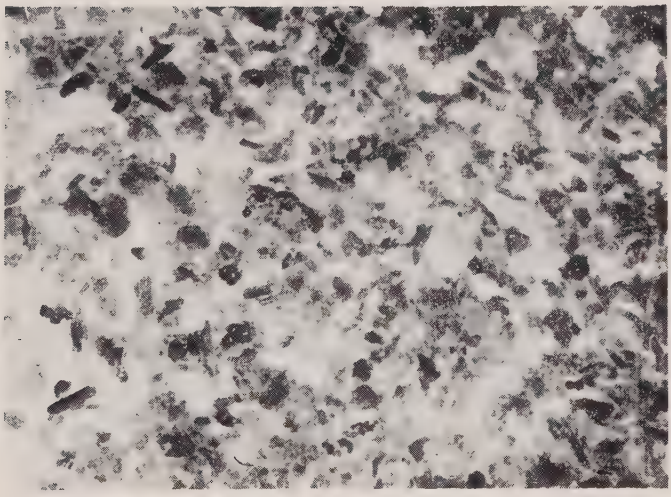


Photo. 9a
Abukuma top soil ×20000

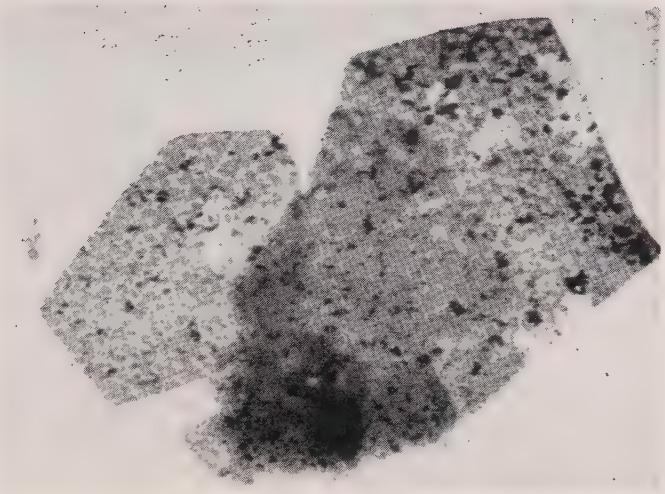


Photo. 9b
Abukuma top soil ×20000

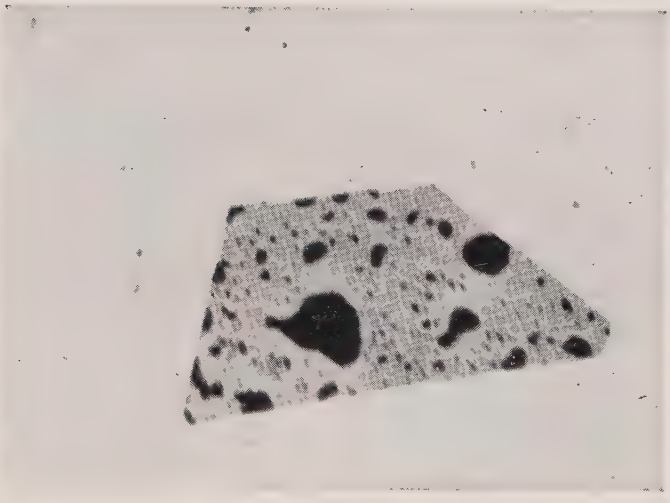


Photo. 9c
Abukuma top soil ×10000

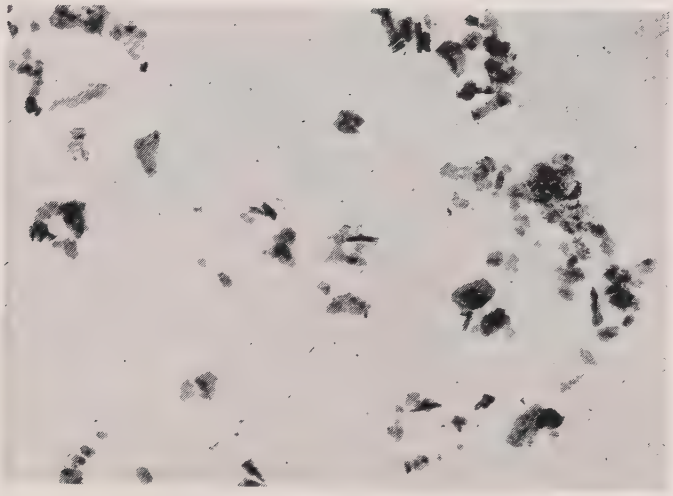


Photo. 10
Semi Clay ×20000

Photo. 11
Daikoku Clay ×20000

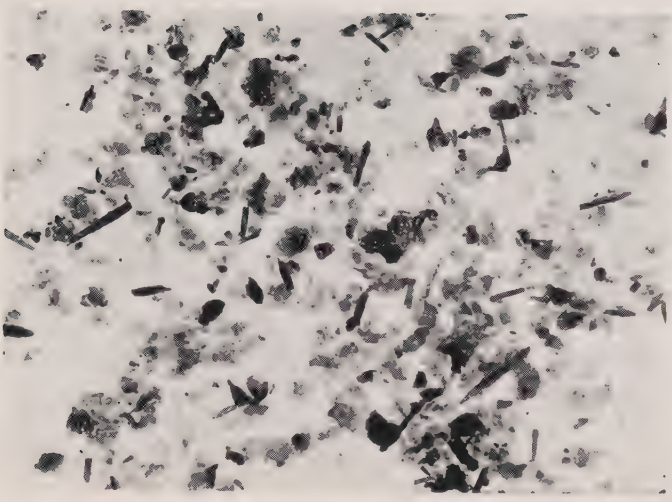


Photo. 12a
Kashii Red soil ×20000

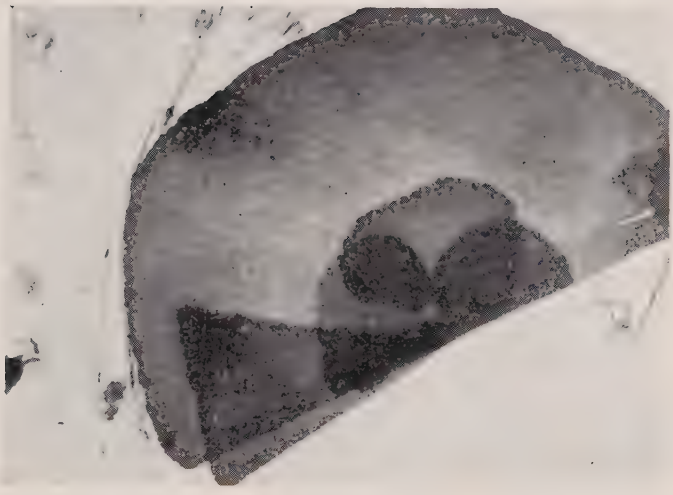


Photo. 12b
Kashii Red soil ×20000

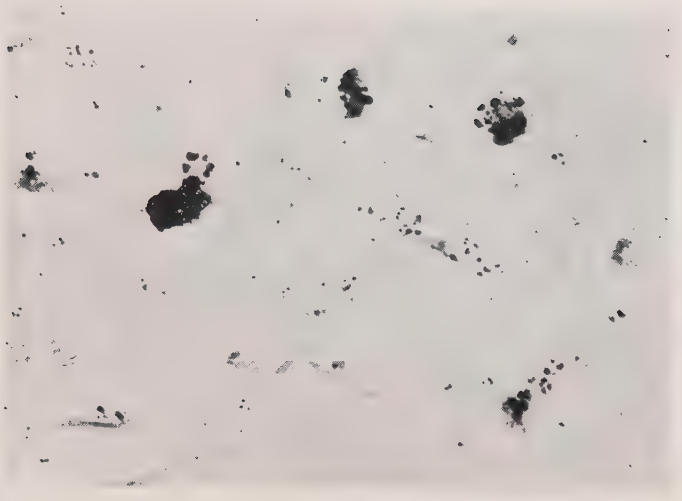


Photo. 13
Zao sub soil. X ×31500

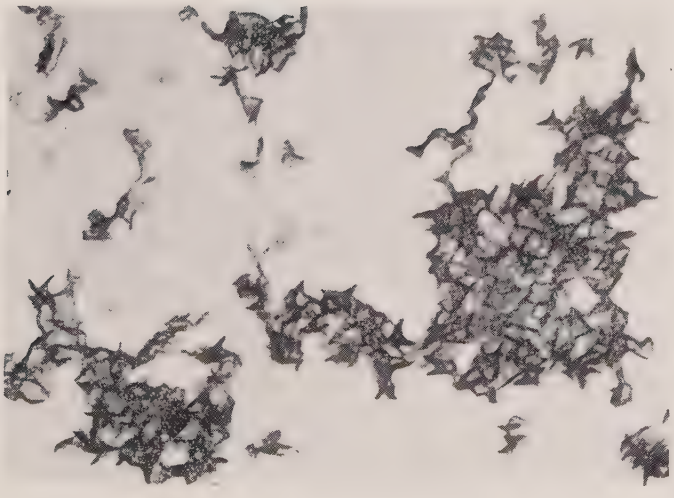


Photo 14a
Zao sub soil. III ×45000

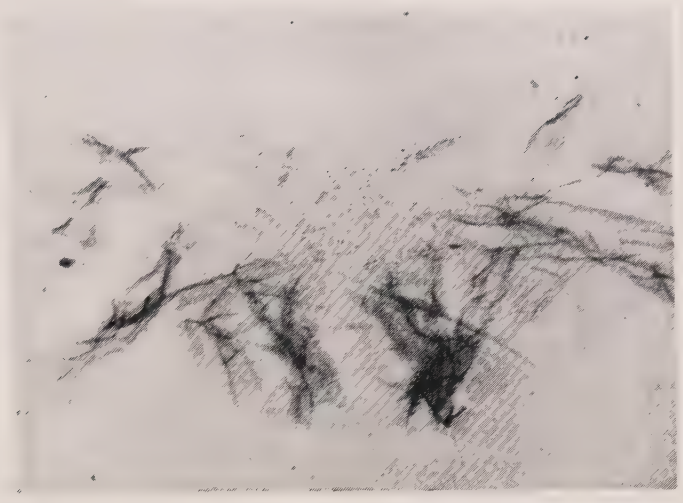


Photo. 14b
Zao sub soil. III ×20000

Mutual Regulations between Commerciality and Self-Sufficiency in the Japanese Agriculture*

Shigemitsu SUNAGA

(Recieved Aug. 1, 1951)

I. Agriculture in Self-Sufficiency

The agriculture most important industry for the feudal period stood on base of self-sufficient economy. In community of village with forest and pasture land the three fields system ran and it was entirely operated on the self-sufficient economy. In the community farmers were able to produce domestic animals and manure for arable land. To keep on the self-sufficiency, they had rule, under which the community's members had no crops, domestic animals, timber, feed and straw for sale without the community's consent. That was demanded to keep the economic system. Undevelopment of work into specialization was laying under the basic system of the community in the period, but reciprocally the agriculture on that social tendency also had to walk along with the system to sustain itself together.

The agriculture means yielding of most of necessaries of life, which is of course available to the producers too. There is large number by kind of the necessaries. Each kind is ordinally different of social rank or position and of civic refinement in the community. Generally farmers who has role to produce the necessaries, sit on lower seat in social class and their life is frugal with the plain necessaries, while the self-sustaining is not so easy to operate. It is said that farmers simply took the three fields system only to make the crops and the domestic animals upon the self-sufficiency in the community during the period. That system seemed to be very simple to mainly produce the crops and the animals, however they had to grow up other crops from their freehold land out of the community and timber or feul from their *allmende*. That is why in the self-sufficient farm producing in the feudalistic community, the farmers must breed so numerous crops otherwise they were still then having the nature of gathering agriculture as their life was very humble.

The three fields system was simple only tripartitely repeating the autum

* The 73rd report of the Institute for Agricultural Research, Tohoku University (1951).

wheat or barley, spring wheat or barley and lay land fallow. Later on grass was raised on the fallow land for feed to livestock while making the land fatile. For the same purpose gradually grass, vegitables and beans were grown on the fallow land improving the soil. We herewith recall to mind that in the period people just lightly raised the principal crops, feed and grass for fertilizer. This had not effected on decreasing sorts of the self-sufficient farmproducts in the feudalistic community neither than this promoted to multiply sorts in hard situation to market necessaries with outside of the community. To support the household on the self-sufficiency they should farm numerous things for example ; materials for textile, oil or edible oil, dyestuffs, vegetables, fruits and spices not excepting the staple foods and grass for feed.

On the standard self-sufficiency of the feudalistic agriculture simple farming was demanded on fields of co-operative cultivation with the three fields system though the farmers had to breed numberless products in their freehold land to support the household. In spite of that the planting was simple on the feudalism, under principle of the self-sufficiency the farming was operated in intricacy out of order and control, getting the sorts of the products multiplied.

The community of feudalistic farmers organization turned away from the development of commercial economism as well as the economic history gave us an explanation. Since the commercial economism thoroughly spreads on villages from urban industry, the feudalistic self-sufficiency lost its potency. The process to the extinct of the self-sufficiency is not now demanded. What is important to mention the relation with urban economy and the three fields system ? On the system they had co-operative farming under feudalism and of that they make the staple foods and feed for all livestocks in the community beyond they had keep the land fertility. Then they had no crops and hey for sale without permission of the community-members.

Nevertheless urban industrial revolution and its rising depended on countless labourers who did not work on any food crops, moreover it requested them skilful working and hard labour sharply different of old manual industry ; that required mass nourishing qualities especially gross of meat to support them. Effectively meat needed of a considerable quantity went into the urban district. At a glance the three field system seemed to lose its place in the self-sufficiency out of the situation. The old trading system inside of the community was broken by selling of the crops or the livestock into the urban district and no longer these came back to the community meanwhile against the crop production decreasing and shortening of livestock nobody was able to restore the community. The time was over upon the system setting on.

After the three fields system was broken the urban meat demand was not decreased. Because of the urban industry was not yet mature, loaded

fertilizer to the villages for cultivated land areas of crops sent to the urban district was not plenty enough. Many years passed away untill artificial fertilizer or others entered in villages as commercial goods. That made villages take rotation system through improving of the three fields system. Not only this caused abolition of the feudalistic rule worked in the community, but also quick development of commercial economy there promoted the translation. At the improved three fields system people made land fat by grass, vegitables or beans-cropping on fallow land. Afterwards two methods arised from this, one of those had triple-form like six fields or nine fields system arranged the plantation to force harvest-increase. Or else in another way they grew vegitables, beans and clover between autum wheat and spring wheat making certain areas became rich of barnyard manure. This latter method known as Norfolk system taken first in the same name place in England, is sometimes called rotation system. This farming descended from the increased urban demand of food for what they need artificial fertilizer to breed crops and ceraels for sale, but fertilizer was not yet prepared plenty for them. For the market demand and agricultural interior fertility to be well-balanced, market product and self-sufficient product should be effectively worked up by turns. The modern rotation system increased for market production, but it was amongst the self-sufficiency because fertilizing and the animals' feed were not fully commercialized. The farming also made an effect on labour and land dividing proportion as in the manufucture, to have its output ever-increasing by means of each partial progress. On the system a considerable number of demanded plants and others related with these to keep the self-sufficiency, not only the simple plants bred on the three fields system. Gradually the simple plants bred for the household and grown in their freehold lands for example ; plants for textile, oil or spices kept off after better ones were commercially carried in on the rotation system, thus minimum kinds were selected from the numerous plants raised on the self-sufficiency. The commercial economy stretched over the villages through this variation. Advancement of the rotation system is not clearly drew with figures. It started at the begining of development of the capitalism. The urban industry grew along with extension of marketing that refrected nationwide its own operation with the prosperity. The rotation system was formerly taken to commercialize the farm products, and herewith more quantity meant more profit. To sale mass crops, cultivated larger areas must be. On the rotation system arable land should be separated technically. Accordingly one forth or less than is available for even most marketable highpriced crops, some these are not easily suitable with the soil. Therefore on the system, I can say some are suited with the soil, and others not. And on acconnt of the market valuation, size of the planted areas shall be varied. Provided that the highpriced crops get well with certain soil, whole areas want

to be planted of these I think. The standard rotation system moved alongside the marketing. The movement is forced by the market demand and that depends on natural environment around farm land. Beyond the movement, finally, simple products are farmed to market, for the purpose of larger profit. And modern single farming is formed. Especially it is worked for example: grape, oil or cotton each on properly suited fields. Of caurse these farming are operated after systematical change of the rotation system, with entire development of farm products commercialism and rich providing of feed and fertilizer what depends on the domestic animals and invention of farm utensils. An establishment of the modern manufacture produced those and the specialized working also are requested. Summarily, according to the progress of the modern capitalism, the agriculture is capable to reach the single farming abolishing the self-sufficiency.

In this view the self-sufficiency in the agriculture lose it's place on the way of normal development of the capitalism and ordinally takes itself on to modern single farming. Besides the question whether the capitalism sets the agriculture inside of a nation or outside, I have now found where is the agricultural economy going to, changing itself on current capitalism; the agriculture has place in the capitalism. I herewith explain what the agriculture turns out losing its self-sufficiency on the way.

II. Self-sufficiency in Japanese agriculture

In Japan the agriculture did not progress on the way illustrated in the former chapter. Though our economy developed highly up to the capitalism, the agriculture stayed on self-sufficiency with the small scale farming, not with profoundly ploughed rotation system. I would not like to toutch the character of the Japanese capitalism left numerous poor self-sustaining farmers in the community, because of many reports were already published.

It was far before that the farm district slightly had entered in the commercialism, in the feudalistic period it already started on. So we see the articles for the farm production either necessary materials for life were commercialized any way. The agriculture in feudalistic society was ordinally self-sufficient on the natural economy, but besides of that it took also commercialism in it as it stood upon the social and soil condition with the economic exchange. This explains us that the agriculture was loosing place on the self-sufficiency; however farmers had to gain cash money selling foods of equal sum of the necessaries. About 150 years ago called Bunka and Bunsei periods farmers in Kinki region where Kyoto and Osaka located now, had bred much to market. At that time farmers bred rape-seed for the oil in Kinai district, but nearby in Mikawa district people did not do the two-crops farming on the rice fields successively. Eijo

Okura a scholar of the day instructed in his book Koeki-kokusanko (Viewing Industry. Literaly : Popularly useful viewing of the national industry) that to feed every thing to market was necessary at that feudalistic community. He said "Famers have to raise rape-seed. If they breed it to market, could be afford the employees, manure or Sake (wine that needed too) at the rice transplanting season, then they had not used having even pocket money... If they did not do the rape-seed farming they should then have debt. It was quite pertinently recomended to do two crops farming with the rape-seed on dryed rice fields for the broken time." On this book we see how earnestly they wanted to be afford expenditure for the employed hands on the small scale farming. They must breed to market utilizing land at it's maximum. If that remained unable to be done, they had burden of usuries stepping out of the self-sufficiency ; they towarded to the seasonable fertilizer purchase and labour-hiring.

On the situation caused in the community, the commercialism largely spreaded over there after Meiji era sprouted out of the feudalistic organization. In the Japanese feudalism manufacturing labour power was not so sharply demanded that it did not breakout the village system upon the routine small scale farming. As soon as land jobbing was permitted under new land laws created from the feudalism, the great landowners appeared getting large areas by the usury. We found that the large land ownership did not yet mean the modern large scale farming. Otherwise the urban industrial development had gathered big labour-population and the most farms forced to market what demanded farmers sale gross of foods. But most of the tenantry had to pay the landowners the landrent, then the owners used to gain almost of all harvest except the tenantry's homeuse crops. The landowner took the important rule on the farm products commercialization while the tenantry had used to keep only the family earning staple foods. About the principal crops, the active producers as tenantry did small scale farming operated by family hands for they had no crops for sale except the home-use or else only a little bit because of they made these by the family hands. Generally the tenantry had only the family labour depended on the self-sufficiency. Against the social progress the farming in the Japanese agriculture remained within the limited development just around the labour power expended to gain more harvest increased. The marketable farm products now stabilized on the tenantry but its commercializing couldn't increase being resisted by the limited farming.

On the industrial development in the urban capitalism the standard capitalism ever leads the commercialism of farm products and living materials against the defending wall of the community's self-sufficiency. So the self-sufficient agriculture was operated on free laboured farming and it had usually taken implements which saved much the labour expend. But in Japan to sale better quality of rice,

people first wanted to have good machines. Farm inplements were made according to the above mentioned situation. Far from the old time the tenantry had to support the household oweing high tax and landrent. The trading materials naturally increased the output. Now I wish to lay an emphasis upon the using of rich manure. The chemical fertilizer was made between the 19th and the 20th century from that time most of farmers bought and used it. If some one did not use it, he could hardly pay even the landrent. The traded materials for farm products should increased the output. But we here see the specific condition to use the new productive powers in our village community. Any where the commercialism entered in, there were no farmers who could keep on the perfect self-sufficinecy.

The commercial materials for the self-sufficient farming made the labour power surplus ; the farming system was going to change. If this way farmers had to buy the materials, they also had to sale much more and they had to gain more areas to plough than before. That caused awful emulation on the land and made the rent higher moreover they had to sale the products or the labour. Farm products-selling forced sometimes the marketing hastened besides in case some farmers had no crops for sale, they should have a by-occupation or they must work somewhere away from homes. It was an independent small scale producing, keeping its point in the capitalistic commercial flow however it seemed stepping out of the poor farmers cottage going towards a change. To change such a self-sufficient farm not only spreading of the commercialism simply helped but also the inflation and unbalanced marketprice between manufactured works and farm products which caused the progress of the economic capitalism. Effectively the community's inflation had quite often made the farmers to remove into urban district with their landlost. Accordingly some of them tried to go in the commercial agriculture from the self-sufficient agriculture, the poor farmers still continued farming in small scale system yet on self-sufficiency. We now find doubled difficulty in the Japanese agriculture.

III. Market agriculture in Japan

We explained in the former chapter that development of the economic capitalism made the tenantry lose the self-sufficiency besides the class was divided into two groups of labourer-like by-occupation farmers and others who took service to the farm products market thriving. But this was a change on the surface ; each group still had its roots deep in the self-sufficiency. If the landowner did good marketing, the crops to market simply came only from the considerable size of the worked areas. At another spot, if large family with unlarge land had small crops or nothing for sale, the household should be supported by by-occupation. In a single rice farming district it showed us a simple model : Commercial agriculture, which increased the commercialization according to the

size of arable land made living of the farmers stabilized with certain size of areas. This is not capitalistic agriculture. It belongs to the markct agriculture, selling the leftovers and the selling had paved the way for the profit. We hereby draw up the individual progress of the Japanese agriculture, comparing with that of European. At first, we see in Japan the self-sufficiency was not quickly changed by prosperity of the urban crop-demand. It showed that there the standard rotation system was not on. Till then to produce for market new agriculture was not raised up from the fall of the feudalistic agriculture. Second, usually the landlords in the feudalistic period, and after the Meiji era landowners were rice sellers. Most of the producing tenantry had not taken the service being to have very little to sale for long time. Third, there is not modern single farming as like as the modern rotation system was not operated there. The marketable farm products took single way with fertilizer and farm utensils but this was not complete answer to the Japanese agricultural modernity.

Japanese agriculture thus standing on the community of the commercial economy kept its place on self-sufficiency but unreasonably it made crops to market. Besides the overpopulation in the community resisted the solution of the small scale farming. This way farmers faced with polygonal agriculture, as well as they tried to make the agriculture commercilized with the rural industry and by-occupation. The market agriculture crooked of the small scale farming was partly operated in Japan and we think that the farmers tried to find a solution to the problem.

People generally say the market agriculture is formed on the process from the self-sufficient feudalistic agriculture into modern capitalistic agriculture. There people has larger areas to raise up the crops to easily support their family. They make greater deal output by the new technics. While rural population reduces of immigrants into swelling urban districts for in villages labourers' class is formed by forced demand of the labour power and of the agriculture made machinalized, thus the manufacturing of farm products and also its selling route is widening. To raise the marketable crops, they have to much work with different manufacturing for each of such variation. In brief, the peculiarity of the situation meant community's change suited to the capitalistic producing, of which the community reached the market agriculture under technical method to match. That made the farming specialized by localized production and its operation bore new mutual economic exchange system. This system was again enforced being helped by the urban industry with the farm utensils, fertilizer, equipments and materials for the farming.

After farm products became commercial on that tendency remunerative selling was earnestly desired that required more employees on the agricultural and manufactural industries. We see contradiction with the rural population reducing

while the labour power demand steps up. The active economic exchange system between villages and urban districts or between one village and another markets met briskness all over the nation. This was the economic shape of the market agriculture in general.

With the disturbing condition remains of the tenantry system, family hands farming and of the self-sufficiency, our market agriculture had not lost the essencial economic quality properly own. If we regard around the dairy farming and the fruit farming viewed as staff of the market agriculture the production is peculiar with the farm products selling and developing of its manufacturing, technical betterment of fertilizer, drugs and the farm inplements. The employment of the labourers also largely climbed aloft in the economy, the activity walks through the nationwide markets. Whereas this advancement is occured not thoroughly on the simple small scale farming but it is held by the strong self-sufficiency of the agriculture and sometimes it shows us an antinomy of substancial phenomenon disguised dubious. There we have theoretical problem that came from the farmers sustained by the commercialism and the self-sufficiency. Far away from the industrial manufacturing, in this market agriculture many distinctions are seen even territorial or characteristic of the farming worked up by individual families. I think it is so much hard to grasp the substance of the Japanese market agriculture by the data of the complicated phenomena.

For instance, I will analyse the growth of the market agriculture. In normal progress the market agriculture had larger scale than that of the family labour's but in Japan it is not always so. For example: If some one farmed an urban vicinity raising cows, hens or flowers in green houses, they surely hardly can stand on the self-sufficiency with mere smallest areas not enough for the homeuse crops. Large farmers however used to get homeuse crops from their own land and manage the croping by the family hands. Generally in the market agriculture farmers still have a bit of the self-sufficiency or just a little more than a bit. In Japan farmers mostly made large family co-operative of grandparents, parents, brothers and their families, that have not yet organized with the modern family system. Thus there is mass self-sufficient crops and the poor farmers have to raise the principal crops over their entire areas. In the grape raising farmers' group in Yashiro Village, Yamagata Prefecture 7.5 tan (Tan is about 0.245 acre.) for rice, 3.5 tan for vegitables, 3.3 tan were for the grape while average areas had 14.3 tan for each household. The produced rice are mostly for the household but some portion of the products are sold. There were 35% of rice output for sale or the government quota deliverey. When a farmer comes to the top of grape perception, he can scarecely support the household with no rice crops for sale or the requisition. They raised the crops on the rice fields for the homeuse of 65 percent and had the rest for sale. In an apple raising

farmers group in Shimizu Village, Aomori Pref. the average size is 16.8 tan for each household, 4.6 tan of which is used for rice fields, 3.8 tan for vegitables and 8.4 tan which means almost 50 percent of the whole area for apples. This percentage is bigger than that of the grape raising which is 23 percent.

The fruits net income is larger than that of the crops, whereas the self-sufficiency restricts then to expand the areas to the fruits plantation remunerative. The self-sufficiency limited the expandation of the areas used for the fruits.

Since the commercial agriculture stood on the self-sufficiency, it fixes certain relation on the land variety of farming areas. The proportional relation is fitted by the demanded feed as much as the products grow remunerative. Besides on the condition raising the homeuse crops though sometimes the proportion is shaken by the actual situation of raising methode or the family hands' number. This is the reason why on the fields for rice, vegitables and fruits the rate is like 2-1-1 in almost equaled ratio of some entirely upleveled farmers in the Yashiro Village. Out of this rate the last number grows heavy as much as it is commercial but it never has sank down to lose its self-sufficiency.

The commercialized rate of the farm products for market are of course higher than the self-sufficient products, though these also are for sale any way that is the outstanding point of the small scale farming system in the commercial economy. For example: There in Yashiro Village it showes 35 percent of rice is commercialized, 45 percent of wheat and more than 90 percent of grape. Of course some farmers mainly growing for market have no rice or wheat for sale.

To produce the staple foods the farmers have to hold large family. And the condition under which the commercial farmers raise the staple foods with the marketable ones pushed the family number up higher. In the rice farming districts the family number is not low but in market agricnltural villages it is higher, for example 7.9 in Yashiro Village and 8.0 in for Shimizu Village, those are considerable number I think. Generally people tried to get the commercial crops improved, increasing the output much over the limit of certain size areas worked out for the domestic use. That drove this "farm to market" to the intensive agricnlture. Then they need large family. The lands of the self-sufficient farming become extended to these of the commercial crops cut down. To give effect to intensive apple or grape farming, the producers needed practiced skillfulness, depend on the family labour power for the commercialism. So this skilled labour is sustained by the domestic foods depended on the family hands that is measured very low or sometimes do not even pay the expenditure for the farming and finally this is cut down. Accordingly the crops become cheaper and the unstabilized tendency do not get with the crop selling farmers. The first blokers are thus born from such economic conditions. In Shimizu

Village over a half of the community's yields used to be sold to the blokers who did not pay between 50,000 to 400,000 yen to each household. This is the reason for which the blokers exsisted in Japanese market agricultural region.

The neccesity of the family labour sustaining comes out from the intensive market agriculture, which made a rule for peculiar labour distribution. The market agriculture keeps many family hands on the highly intensive farming but in the busy planting season the labour force is demanded much more. This should be filled by engaged employees many more than the single rice cropping farmers' need. Originally the commercial farmers have to get also employed labourers and machines. In the Japanese agriculture however no implements or equipments without the spray are carried in on the fields of the domestic use and the marketable crops which still remains for the small scale farming. According to the relation the scale of the market agriculture is rather smaller than that of the self-sufficient one and besides those machines are hardly taken. However the employed labour is used on the self-sufficient products, while the domestic labour is taken for the marketable products that are not for their homeuse. In category of self-sufficient agriculture the domestic labour should be shared the self-sufficient crops and in the modern agriculture employed labour should be operating on the marketable products. As the self-sufficient crops are not needed good quality so it may be producted with simple labour, while the market crops are demanded high quality must have been entirely improved by practiced hands. Most briefly, skillful experience must have been owned by the family staff. This conclusion reaches a doubled antinomy. This meaning brought up a limit to expandation of the market agriculture on a problem around labour power.

We now could say that the commercial farmers are independent. Rice crop farmers of less than 18 tan are usually supporting the household with the jobbing work or by-occupation at least, though the commercial farmers very scarcely have such jobbing works. The commercial farmers with about 5 tan sometimes work away from home but they are still independent. For this the labour engagement demanded for the market agriculture is usually gotten from the others than the commercial farmers. I wrote before about the marketable crops should be planted on the suitalbe land. Nature now keeps a condition, in a certain village some crops are suitable with the soil but others are not on another lands; under this condition working hands used to be employed from the areas which soil is not suitable for the crops. It means that the elements of which natural condition forces certain farmers self-sustaining and other ones have taken by-occupation. If some ones gain high revenue by the market agriculture, they do not need any by-occupation to make such a fortune but it does not often occure. At this point we see that the cultivated areas of the commercial crops shall

not be enlarged easily. In Yashiro Village in certain settlement of special European grapes (such as Black Hamburg and Muscut of Alexsandria) are suitable to the garden plantation and on the larger slope while other the local grapes are raised on ground less than half in the same sttlement. There in the settlement people has received employees from other communities having no grape farming.

These made figure upon the higher farm income than that of by-occupation at the commercial household. In Yashiro Village only 2.8 percent for by-occupation income, 75.8 percent for farm income and the rest 21.4 percent was for estates-interest without counting the size of farm land. (1949) It shows us the independent quality of this farming. The sum of income was also large. While the average 170,000 yen for farm income in the rice farming tract, 320,000 yen was for the grape farming tract in same year. The average net income, was 21,700 yen per tan in the grape garden farmmg while 8,871 yen for a hausehold in the rice farming. Though the size of fruits garden was least, the income was highest. This mutual relation, I would like analize with the real figures but I had an opportunity to do that before,(1) and I do now express mere spot.

What is the characteristic Japanese agriculture? It raised from the smallest farming to obtain profit on fundamental self-sufficient agriculture. Effectively it could not develop itself on the situation in the rural overpopulation with the substancial influence of the current from the capitalistic economy. So that even commercial farmers had to keep large land to the self-sufficient crops though for the costly commercial crops rather smaller areas laid there. I ever mentioned on the above page that the farmers demanded intensive family power for the markebtale products. Consequently, the large family had to cultivate for the domestic crops on land of considerable large size expanding into the fields for the market crops. After the exhaustion of the family labour, they minify ability to manage whole products to sale and their labour force itself. Then the revenue goes down while the blokers become fat. More than that the family labour was put upon the farming to market while the employed hands helped the self-sufficient raising because of short labour. These farmers however gained higher income by the growing to market than that of those who farmed on the one rice cropping a year. In Japan the market commercial agriculture stood on certain ground as the usual in many other countries and indeed it made good growth of nationwide market with the fertilizer and drugs advancing the manufacture to develop. The Japanese market agriculture goes from within the thick walls of the poor small scale farming with the rural overpopulation that is why it still takes way of contradiction to go ahead.

---

(1) Sunaga, S. Studies on the market Agriculture in the Tohoku District. Bull. Inst. Agr. Res. Tohoku Univ. **2** (1950) 305, 515. **3** (1951) 32.

Summary

Farming scale of the Japanese agriculture is small and still little conservative observed in social economy because of the self-sufficiency upon feudalism. But in Japanese trade and commerce the capitalism advanced in developing. On this occasion the Japanese agriculture stands between the feudalistic and modern economic system. I studied the problem theoretically and historically, and the results obtained are summarized as follows:

1. On self-sufficiency of feudalistic agriculture, the famers' living standard was low however they had to raise numerous and necssary crops in their fields. After the capitalism extended over urban districts where grains and meats were largely supplied from villages. Herewith instead of the three-fields system the rotation system carried on to produce to markets. Gradually the farming was improved with chemical fertilizers and others, that events lead the rotation system to the modern single farming.

2. I hereby have to say that the Japanese agriculture never developed up to the modern single farming through the rotation system. At the end of the Japanese feudalistic period farmers began to bear the market crops, though in the followed capitalistic period, they were yet poor on the self-sufficiency: For instance; tenantry had rice for only enough to support their family. And landlords whom the tenantry paid the raised rice for landrent, took roll to sale it what was at the top of farm products' output. As soon as the commercialism spreaded on the farmers communities, they sought way to sale the crops made by themselves. Because of the Japanese farmers with large family cultivating unlarge areas, scarcely could have enlarged lands to bear more crops to markets that really caused increasing the landrent or rising of land-jobbing. An intensive cultivation was finally operated in Japan with the chemical fertilizer, seed-selecting etc. As its results the Japanese farmers have self-sufficient labor power while they due to farm products for their proper demand and to markets, purchasing the farm materials from urban districts returning back.

3. In the Japanese market agriculture on the self-sufficiency, the following relations are noticed:

i. More than a half of the farming fields is for the croping of staple foods and the rest of smaller plots is used for the products to markets. Consequently a certain propotoinal relation is remarked on account of described facts.

ii. Most of the commercial farmers are independent without by-occupation: They are afford to sustain a large family.

iii. In the market agriculture they mostly keep the engaged labor for self-sufficient crops, oppositely they have their own power for market crops which are needed the technical skillfulness to grow them.

On the Self-Sufficiency in the Farm Management*

Kan-ichi YOSHIDA

(Received August 15, 1950)

I. Introduction

Of a total of about 5.9 million Japanese farms in 1947, 2.81 million, occupying 47.6% of the total, belonged to the class of "farms 80% or more of the products on which are used for farm-consumption." 29.08 million *koku* out of the estimated total rice production of Japan of 58.6 million *koku* for the same year was delivered under the rice collletion program of the Government, the remainder being consumed on farms, that is to say, only about half of the rice crop was sold.

Besides the rice, crop most representative of Japan's agricultur, it would be easy to observe also in other crops, except for some kinds of fruits and industrial crops, their character as self-sufficiency crops even more distinguished than in rice, without taking any illustrative figures. These facts indicate the something like half of the Japanese farms are self-sufficing farms and half of the production even of rice, most representative crop of our farms, is used for consumption on farms. This means, it seems safe to say, that the most important part of the farm management in Japan has not yet reached the stage of the commrcial agriculture. The same thing is readily observed also in the singificantly high percentage of the self-sufficient part in the composition of the productive cost of farm products, as revealed by lots of surveys and investigations. In most cases where Japan's agriculture or farm management became the subject of discussion, approach to the problem was made from the standpoint of the agricultural economics, while, I dare say, too little attention has been paid to the question of self-sufficiency.

We have had a lot of arguments in the past in relation to improvement of the Japanese farm management. Each of them seems to have been based on one of roughly two opposite standpoints, i.e. one seeking for development of the commercial agriculture and the other advocating establishment of stalbe self-sufficing agriculture. The arguments from the former standpoint can be said to be

* The 52nd report of the Institute for Agricultural Research, Tohoku University (1950).

founded on the general rule that the farm management should be subject to the rationality of the present capitalistic society, while those from the latter standpoint may be regarded as ones based on the speciality since they emphasize the peculiarities of out farms which are termed "family laboring farms". Of course, there are all modifications among those arguments between the opposite extremes. Also we can not say that very hot controversies have been had between the both academic groups. Neverthless, in a sense, this problem may be regarded as a continuation or reproduction of the past controversy on "large or small farm". Now, even as to the arguments emphasizing the self-sufficing agriculture, it appears very doubtful if they are founded on a definite recognition of the significance of self-sufficiency in Japan's agriculture or farm management. Moreover, inseparability between farm management and house-keeping has become a subject of discussion in relation to our farm management, and also has been emphasized as a specific character thereof, This also seems to be due to lack of adequate understanding of the nature of the self-sufficing agriculture.

It goes without saying that the capitalistic agriculture has as its pre-requisite commercial production in agriculture and is based thereon. In this sense, the self-sufficing agriculture is essentially the agriculture of a society before the capitalistic one, or in other words, it is by nature the agriculture of the society of the primitive communism and middle feudal society. In such societies, farmers produced by themselves not only the means of production but also buildings, furnitures, and even utensils for daily life, and formed a self-sufficing economic community. In the society of natural economy, in other words, production was carried on in veiw of use value but not excange value. Here was the ground for the conservative and unprogressive character of the feudal society. Collapse of the middle feudal society began with the separation of the home-industry from the agriculture, followed by development of manufacturing industry, and development of the exchange economy brought about the shift in the purpose of agricultural production from the use value to the exchange value — production for market, resulting in development of commercial agriculture. It is a well-known fact that this led to establishment of the rule of capital over not only the manufacturing industry but also over the agriculture.

Now, what does the fact mean that, even in the stage of monopoly capitalism the self-sufficing agriculture still plays an important part in the actual conditions of Japan's agriculture? Obvious that Japan's agriculture has not reached yet the stage of the perfectly capitalistic agriculture ,and that no capitalistic farm management exists. Much has been said about the reason why agriculture has failed to be developed into capitalistic one in this country. Space does not allow to dwell on this question here, but discussion on the problem of the self-sufficing agriculture which has received rather too little attention up to the present, will

have to touch on this point in a way or other, for, when we try to find out the reasons involved inside our agriculture why it has failed to be developed into capitalistic one, we shall be met with this problem of self-sufficing agriculture as a course of nature.

It is distinct, at any rate, that Japan's agriculture consists of the parts of both the commercial agriculture and self-sufficing agriculture, and this double character thereof can be observed inside the farm managment as the parts of the exchange economy — money economy — and the natural economy — self-sufficiency (real matter). Then a question arises about what this double character means. Before answering this question satisfactorily, it is necessary to make clear not only the nature of each element of this double character but also the relationship between these elements, and to determine which is more essential to the farm management. For this reason, the following discussion will be centered on the farm management, or the mechanism of reproduction in farm management. Now, on an actual farm, it is easy to recognize two different parts of the management, i.e. the circulation of money and that of matter. However, it is more important, instead of taking up the fact merely as a phenomenon, to find out significance of existence of such double character. That is to say that point does not lie in merely cognizing it but in overcoming it.

II. Reproduction in management

In a capitalistic society, production in agriculture is carried on in the management of the individual farm, and, thus, it is clear that the management becomes the unit of economy and, naturally that of production. As far as the management, then, is the unit of production, it becomes necessary, as a matter of nature, to understand it as conditions of production, which bear economic characters. Now, since "the conditions of production are the conditions of reproduction at the same time,"(1) the management will be necessary to be understood as the process of reproduction.

If farm management is practised in a capitalistic society, reproduction in such management naturally must be a capitalistic one.

Reproduction in a capitalistic society can be illustrated by the following formula :

$$G — W \ldots . P \ldots . W' — G'$$

Needless to say, the circulation of capital completed through the above three different phases is to be observed also in a farm management. In actual conditions of a Japanese farm management, however, reproduction fails to take such form, as mentioned previously. All the farm products are not marketed, but a part of such products are directly used for farm-consumption — productive consumption. Therefore, the process of reproduction in the form of money

can represent only a part of such reproduction, and there exists the other part of reproduction in the form of matter, which can not be shown by money. If production takes a capitalistic form, so does reproduction, too, as a matter of course. If the capital, therefore, is reproduced with capital, and real matter with real matter, the reproduction on the Japanese farm shows two different forms, that is, reproduction of the part which takes the form of capital and that of the part which does not. These two different parts are present together in the process of production but separate from each other in the process of circulation, only the former part entering it. Consequently, the process of production reveals the management in full but the process of circulation only a part of it.

Therefore, the mechanism of reproduction may be illustrated by the following two different formulas:

$$\text{I.}\quad G - W \ldots P \ldots W^{\circ} - G \quad \text{and}$$

$$\text{II.}\quad W \ldots P \ldots W^{\circ}$$

Since W and W°, both in I and II, are equal in their use value, they come into one in the process of production in actual conditions. On the other hands, if the management is understood as reproduction of capital, G must be equal to W and W° to G. In actual conditions of the farm, however, G does not equal W, nor W° equals G.

To illustrate the reproduction in management, therefore, in a more correct way, we must have:

$$\begin{array}{ccccc} G & - & W & & W - G \\ & & \| & P & \| \\ & & W & & W \end{array}$$

Here we can see definite disagreement between the process of production and that of circulation in the reproduction of management. Is it too much to say that we can see the nature of the Japanese farm management in it? As far as the process of production is more essential to the management, this double character observed in the process of production may well be said to characterize the farm managment in this country.

Then, a question arises about why such mechanism of reproduction has been set up. As far as this question is concerned, the circulation of money may be just put aside from the course of our discussion. Point is, thus, why the circulation of matter W .... P .... W° takes place. Sure that the circulation of matter can not be accomplished without the circulation of money, yet these two things may have to be considered separately just here.

The circulation of capital is completed through the three phases, namely the first $W' - G'$, the second .... P ...., and the third $G - W$, as mentioned above. The circulation of matter which is confined to the inisde of the management can be said to lack the first and third of the above three phases. The

reason will follow. The direct form of circulation of commodities is W — G — W, that means to sell to buy. The circulation is illustrated in a more detailed way by W′ — G′ — W .... P .... W′, in which the movement starts from W′. Now, W° reaches W through the phase of G, because a qualitative difference in use value between W° and W is sought for. In other words, exchange is made because value is same while use value is different. Therefore, if W° and W are of same quality and of same use value, the process of circulation of commodities W° — G — W will become unnecessary, and, as a result, the circulation is short-cut from W° to W, thus the circulation of W — W° being repeated within the management. This logic indicates that the reason for the circulation of matter, or farm-consumption, lies in the problem of use value of goods. Whether or not these W and W° are of equal use value and, how the quantitative ratio in use value between them will be determined are different according to the kind of industry concerned. The ratio is larger in agriculture than in manufacturing industry. But it will vary within agriculture again with the kind of crop or domestic animal concerned. Now, W represents the means of production and labor. To the question which of these two has more of common use value, there will be given an essentially same answer as above. Besides the kind of industry, the productivity of the industry concerned is important. If it is low, it can be said that the common part of use value between W and W° becomes larger in quantity. If lower productivity means more labor, it will cause increase of common portion of use value between W° and W. This view will help us understand the reason for high self-sufficiency on ricefarms in Japan. Moreover, it becomes clear as a matter of course also that the surplus population in rural areas acts as a factor for increasing the above common portion of use value. To conclude, the most essential reason for the reproduction of matter as such carried on within farm management lies in the problem of use value.

Another reason is the problem of value or producitvity. The historical evolution of economy from natural to exchange economy and development of agriculture from self-sufficing to commercial agriculture have been made possible, above all, by development of productivity. This means that, without development of productivity there could not be commercialization of farm products. The reason is that as far as the circulation of commodities starts from W° (product), if the products are to enter the process of circulation as commodities for market, there must be any surplus of products after satisfying the need of the farm family. Therefore, in the stage of economy with low productivity, there can not be any circulation of commoditeis, all the products having to be used for farm-consumption. In short, increase in productivity is a pre-requisite for commercialization of the products, and, as far as this pre-requisite is lacking, there is only farm-consumption, or the circulation of matter. Now, for the

possiblity of this pre-requisite to become reality it is a matter of course that there must be absorption of rural populations and demand or farm products. In the case or in the coutnry where the capitalism in agriculture has accomplished its normal development, we must understand, the possibility has been cnoverted into reality. It is true at least in the stage of industrial capital. Indeed, if such conversion should not occur, the productvity of agriculture, would be prevented from being developed.

Once the products have entered the process of circulation of commodities, they must bear the expenses of circulation. In cases where the productivity is low while the expenses of circulation become too heavy a burden to bear, development toward commercal agriculture will necessarily be checked just by such difficulties in the process of circulation. As is widely accepted, because the expenses of circulation are non-productive ones, prodectivity is required to be raised enogh to bear them. Even in cases where productivity has reached a substantially high level, if the burden of the expenses of circulation is especially heavy (as may be the case in the stage of monopoly capitalism), commercialization of farm products will be necessarily prevented, just as in the case of low productivity. In the foregoing paragraphs, we have discussed the circulation, starting from W° (product), to determine whether or not the products enter the process of circulation of commodities, or how the corculation of matter occurs. In conclusion, we can say that the problem of use value provides principal causes for retarded development toward commercialization of farm products while another cause comes from the question of value in the process of circulation of commodities in some cases, resulting in greater emphasis on the circulation of matter. That is to say that if value and use value produce reverse effects in conflict, such condition works so as to give more weight to the side of the circulation of matter. Thus, the reproductions of G as such and of W as such come to be repeated. Also, W° — W occurs because of equal use value, but whether the products (W°) enter the process of circulation of commodities or follow the course of the circulation of matter is determined by the process of production, or, in other words, the nature of the process of production is directly reflected on the products concerned.

It is important then that, if capital can become, instead of being just money, the money which begets money only by being used for buying labor with it, commercialization of products must necessarily be at a low level in the stage of simple commercial production in which the manager himself owns the means of production. Therefore, even if there is surplus labor, it would, without being accompanied with purchase of such labor, not become a factor to encourage commercialization of the products, but, on the contrary, would produce the effect of increasing the reproduction of matter as such. It is because surplus labor

results in increased consumption in matter (farm-consumption) in the process of production. It is needless to say that the farm management in Japan is really under such conditions.

We have discussed in the above the essential charater of the reproduction of matter as such, and now must mention the process of movement of matter. As is to be seen from the points mentioned above, the nattural economy is an econoy in which "all or the largest part of the economic conditions are produced by the management itself, made good and reproduced out of the gross product of the management."(2) Then, it raises a question how the circulaton in reproduction of matter as such takes place. This question may, in view of the fact that the economic structure of the natural economy is based on production of use value, be considered to be a problem of the second one of the three phases of the process of reproduction of capital, the first and third phases being lacking in this case, namely a problem of the process of production, as mentioned above. However, there is a difference in the nature of production of use value between the cases of commercial production and of reproduction of matter as such. In the former case it is production of use value for other people, or unknown consumers, namely with market in view directly, while, in the latter, production is aimed at consumption by the farmer's own family. What will such a difference signify in the actual conditions.

As mentioned above, the circulation of matter can be represented by W—W°, and, in the case, W° (product) is turned into W (means of production and labor) because these two are equal in use value. That is to say that the products can be converted into both the means of production and labor because of same use value. However, that W° and W are same in use value does not necessarily mean that their use values are same in every aspect. Aside from acquisition of surplus products, if W° and W are perfectly same in sue value, there will be no need of production. By the word "same use value" in this case, we just understand that there are some use values of the products among many others thereof, which are common with those of the means of production or labor. Also, since production in the natural economy is that of use value for farm-consumption, as mentioned above, it is at farmer's liberty to produce products of such kinds, as he likes. Thus, it becomes that "the seeds and manure need not be bought actually as commodities, but are taken from the products itself in natural newly to go into reproduction of the same products as conditions of production ...."(3) Now, there is no question about the means of production, but a question may arise what we can understand by the equal use value between labor as such and the products. In this case, an important thing is whether or not labor can be regarded as W to the last. In the circulation of capital, labor is purchased as a commodity, but in the case of the circulation of matter in the natural econoy,

labor has also to be produced on farm just as the means of production. What in the concrete, then, is the production of labor on own farm? It is productive consumption of products as necessaries of life (chiefly as food), that is, consumption of necessaries of life is production of labor. As far as, thus, labor means necessaries of life there will be no question, if the necessaries of life and products are equal in use value. In fact, it is evidently recognizable that W° (product) and W (necessaries of life .... labor) are same in use value. Then, it may raise another question why there is such difference between the cases of the circulation of matter within the management and of the circulation of capital. This difference comes, we must say, from the difference between the society of commercial economy and that of natural economy. It is a well-known fact that the society of the natural economy is more normal than the capitalistic one in view of difficulty in considering the products and labor in the same way in the former, and that, in the capitalistic society, labor must be treated as a sort to commodity in the same manner as matter is really an abnormality.

The significance of the above circulation of matter becomes the next question. First we can see that consumption in this case becomes nothing but productive consumption. Production in this case is one for own consumption and becomes essentially different from production to sell. Such production is in most cases production to eat. In cases where consumption of products (W°) means directly a productive consumption like this, every farm-consumption is necessarily required to be fully utilized for production because the reproduction is carried on only inside the management. Necessity of utilization of by-products, wastes, and even young and old and unskilled labor is to be explained by this logic, and without doing it, maintenance of reproduction will become really impossible. To say nothing of high valuation of vegetable and barnyard manure, use of even human waste is considered to arise from the same conditions.

Next, while, in the case of the circulation of capital, individual consumption may be set aside from consideration as far as the process of production is concerned, things are quite different in the case of the circulation of matter because it occurs just in the process of production. Consequently, there arises inseparability of management and house-keeping. This is, of course, to indicate "die als Nahrungzweig betriebene kleinbäuerliche Agrikultur".(4) Now, in the reproduction of capital, the productive consumption and individual consumption of a laborer are essentially two perfectly different things, though "the laborer is often compelled to make his individual consumption a mere incident of the process of reproduction.... But such a thing presents itself as an abuse not essential to the process of capitalistic production."(5) On the other hand, in the circulation of matter, productive and individual consumptions are essentially the same thing, To be brief, the cirulation of matter occurs within a single manage-

ment independently from other managements. This is what the word "self-sufficiency" signifies, and naturally makes the management to be isolated and conservative.

As has been made clear in the above discussion, individual consumption, in the reproduction of matter as such, is not made on the profit accruing from the reproduction. A perfect individual consumption on the profit is made, or becomes possible, of course, only if the circulation of matter represented by $W^{\circ} - W$ is eliminated. If done so, it would mean to enter the course of capitalistic production.

In short, "in the proper natural economy,.....not a bit or only a very insignificant part of the agricultural product entered the process of circulation,.....," [6] and the circulation of matter is properly understood as a thing under such conditions.

Now, if the circulations of both capital and matter are present in the Japanese farm management, how they take place and what they signify would be the next questions.

In such a management, reproduction of capital and that of matter are carried on separately. Therefore, if viewed from the standpoint of the circulation of capital, combination of these two is made in the second phase of the circulation, or the process of production, and they are not directly related to each other in the first and third phases, or the process of circulation of commodities. We must say, therefore, that the point of the problem lies in the process of production. The two things in question can be regarded as one as far as use value is concerned. In this sense, it can be said that "natural production does not preclude circulation of commodities which, of necessity, has the property right more or less as a pre-requisite." [7] Now, it is also obvious that the circulations of capital and matter are in a conflicting relationship to each other. It is because the reproduction of matter is confined to the process of production in a single management, while the reproduction of capital needs markets, and requires existence of other managements as an indispensable condition. This is a difference between self-sufficing agriculture for farm-consumption and commercial agriculture for market, and production is carried on for consumption of products by own farm family in the former and for profit begot by capital in the latter. Since these two are based on essentially different principles, a management which involves both of these heterogenous, conflicting principles simultaneously must become one, as a matter of nature, of a double character. This is to indicate actually that, to say nothing of the means of production such as manure, feedstuff, livestock, buildings, etc., even labor including family labor (expensee of house-keeping), hired labor, etc. is composed of two parts, one being self-sufficed and the other pruchased. It is because, as these two parts are same, from

the viewpoint of use value, in both the means of production and labor, they are not to be distinguished from each other, while, from the viewpoint of value, they are to be distinguished into the parts with and without value. (The former part is in a conceald form.) In other words, the dfference is not given form in the process of production while it takes form in the process of circulation. Table 4 shows the double character to be observed in manure and fertilizer.

The double character, which is kept hidden in the process of production, puts its appearance in the products. As is to be observed from the quantities of the products (rice) used for various purposes as given in Table 3, the part thereof sold includes deliveries under Government collection program, barters, free sales, donations, and so forth, while the part consumed on farm consists of family-consumption, feeds, seeds, etc. In short, the double character in the process of production is found to be reflected on the products.

In the foregoing discussions, we have understood the self-sufficiency as the circulation of matter from the standpoint of reproduction in the farm management, and also the actual farm management as of the double character of the circulations of both capital and matter. It would be necessary now to touch on the reason why the Japanese farm management must have such self-sufficiency and also such double character, and what the factors which determine this self-sufficiency are.

III. Factors to determine self-sufficiency

It has been already mentioned that the natrual economy is essentially the economy of the primitive communistic and feudal societies. It is needless to say, therefore, that whether the management presents itself in the form of reproduction of capital or matter is determined by the nature of the society of capital or matter is determined by the nature of the society in which the management is practised. Historically, the first stage of development of the capitalism was the separation of hand industry from agriculture. It is an important fact in this connection that the capitalism which had emerged out of agriculture in its course of development has come later on to rule the agriculture. Thus, development of the capitalistic agruiclture necessarily results in the rule of capital over agriculture.

The rule of capital over agriculture is performed through commodities actually. In what manner, then, does the rule of capital over agriculture in Japan presents itself? It will be outlined in the following. So many a view has been expressed to date on this point that it seems unnecessary to dwell on it again. In short the Japanese capitalism, being late in starting, did not succeed in having our agriculture developed in a normal way : Sure that establishment and growth of the capitalism in Japan increased demand for labor and

farm products, and, naturally, brought about absorption of rural labor and encouraged commercialization of farm products, yet it has, unfortunately, failed to go so far as to absorb all the relative surplus population on farms and to develop agriculture to the point where perfect commercialization of farm products was realized. This is not because the rule of capital over agriculture is weak, but because "the problem of feudalism is in the wise one of historical past of mankind.....The capitalism also, especially in the stage of imperialism, maintains, utilizes and even fosters the forms and methods of exploitation of serfdom and suppression of labouring class in the colonies and settlement."(8) Under such conditions of the capitalism, it is of no doubt that capitalistic development of agriculture has to be checked, and this situation becomes the cause of the double character of farm management.

It has been preciously indicated that the character of the capitalism is what essentially determines self-sufficiency of management. Attention is called, next, to the direct pressure of capital. Of course, we can not consider it separately from the essential determinants, because the actual actions of capital come from the essential character of it. In short, what effects the capitalism produces on self-sufficiency in management is determined by, needless to say, the essential character of the capitalism as well as the stage of its development or influence of the capitalism in foreign countries. This direct action of capital on management seems to be performed, roughly, in two ways.

First, we can find such direct action of capital in the adverse flow of population displaced from urban industries to rural areas as well as in the relative surplus population of rural areas which should leave farms, for it is clear from the above discussion that an increase of relative surplus population enlarge the extent of self-sufficiency. Next, the prices of farm products call attention, because the so-called "Schere" and taxes affect the extent of commercialization of products by influencing the farm management as a pressure of capital. Such influence varies, of course, in degree from management to management, as will be discussed later.

Both of these essential and direct actions do not go along always in the same direction. It may occur sometimes that the essential action works to support the self-sufficing agriculture, while the direct pressure of capital tends to dissolve it. What actions will be performed on agriculture is determined by the character, the stage of development, etc. of the capitalism concerned.

It goes without saying that the character of landownership is determined by the character of the capitalism, and also that the character of landownership determines the nature of the agriculture directly and essentially as well. The products rent often prevalent before the land reform was a result of the semi-fuedal landlordistic landownership (It is another question whether the land reform has succeeded in modernizing such character of landownership or not.), but it is

of no doubt that such products rent has served, in turn, to secure our self-sufficing agriculture, for "the products rent can, under certain conditions, change feudal relations from a certain progressive form to a stagnant one".(9)

Though the above conditions affect uniformly all individual farm managements, the effect of such influence can not come forth in a same manner nor to a same extent with all the managements. Extent of self-sufficiency, in fact, varies from management to management. It is because of existence, we can say, of subjective conditions affecting the extent of self-sufficiency.

First of them is the type of management, such as owner-farmer or tenant, indicating the character of landownership, individual or co-operation, and full-time or part-time, as well as the type which indicates natural character of agriculture (to be indicated by products). It is obvious that the type of management must become factors determining the extent of self-sucffieny. Needless to say that, for instance, the difference of "owner-farmer or tenant" will result in a different degree of self-sufficiency, and so will the difference of "rice or dairy farming." The fact that, in the agriculture of a feudal society, such type of farm management as dependent chiefly upon crop growing was prevailing may be considered to indicate prevalence of self-sufficing farming in such society.

It seems to be due to prevalence of self-sufficing farming that specific attention is paid in Japan to the problem of the natural type of farm management such as "rice or dairy farming."

Another condition of management is the size of farm. Extent of self-sufficiency is in inverse proportion to the size of farm. As is shown in Table 3, the average percentage of commercialization of rice crop on all farms is 62.3%, but the percentage of farm-consumption is higher for farms of smaller size. In this view, it is a matter of nature that the extent of self-sufficiency is high in such a very small farm management as prevailing in Japan. In Japan, of course, low labor productivity and overwhelming majority of rice growing farms must be taken into account as additional factors. Therefore, we can not say that a very small farm always indicates self-sufficing farming. Our logic is that, as is to be discussed later, productivity of the self-sufficing agriculture is low compared with that of the commercial agriculture, because the self-sufficing agriculture is an agriculture provided with poor means of production and largely relying on hand labor. Under such conditions, the farm need not be large in size, or is required to be even small enough to be cared for by hand labor. Thus, the reasons for larger extent of self-sufficiency on a farm of smaller size are lower productivity and larger portion of products used for farm consumption, from qualitative and quantitative viewpoints, respectively, Also in this case, of course, the type and size on farm must not be considered separately.

As indicated above, self-sufficiency in the management is determined by how

the capitalism influences agriculture. But such influence does not always serve to push the farm management in a certain same direction. It is possible to occur that it works in the direction of supporting self-sufficiency and, at the same time, of eliminating it. We may see here a self-contradiction involved in the capitalism itself. On the other hand, of course, the own character of the management may give rise to differences in the way in which the management is affected. However, it is needless to say that the conditions of management cotributing to determination of self-sufficiency are direct but not essential factors.

IV. Nature of self-sufficiency from viewpoint of management

It has been already mentioned that production in a self-sufficing farm management is one of use value that is not for sale but for farm-consumption. In this case, low productivity is a matter of course, because the scale of production is determined by the family's desire, and no desire for indefinitely large production can arise from production itself. In other words, needs within the management form the maximum limit of production, and, consequently, such unlimited production for profit as in the commercial agriculture can not be carried out. To be brief, the relations of production work as a limiting factor for production. There can not exist, therefore, any production based on modern rationality. Also, as will be discussed later, since the products in a management have a double character as ones partly for sale and partly for farm-consumption, the management involves two conflicting elements, and the productivity in such management is considered to be determined by which of self-sufficing and commercial agricultures determines the management essentially.

Moreover, as production in the self-sufficing agriculture is one of use value for farm-consumption, the products tend to become varied to the highest possible degree, as a matter of course. This is observed, above all, in the kinds of crops adopted, resulting in scattered operations and, consequently, reduced efficiency of each farm operation. At any rate, we must say that labor productivity is low in the self-sufficing agriculture.

Low labor productivity may be considered, from another point of view, to indicate poor means of production with which the management is provided. Everybody knows with how poor means of production Japan's agriculture, which is substantially a self-sufficing one, is provided. Among our means of production, manure and fertilizer are most important. This is readily observed in the very high percentage which this item occupies in the productive cost, as shown in Table 1.

The table shows that the percentage of manure and fertilizer in the productive cost is far the highest, except for the cost of family labor. This fact will have to be considered to show in an indirect way how important a part self-

Table 1. Composition of productive cost of selected crops (1948).

Items of Expenses \ Crops	Barley	Wheat	Naked barley	Potato
	..... (in percentage)			
Family labor	48.0	46.1	44.0	38.2
Manure & fertilizer	15.9	16.7	16.0	19.4
Taxes and the like	8.1	8.4	8.9	11.4
Hired labor	5.9	4.2	3.2	2.0
Animal power	4.4	9.1	11.3	3.5
Miscellaneous	17.7	15.5	16.6	25.5
Total	100.0	100.0	100.0	100.0

Note: Data from Nôrin Shiryô Jihô (Journal of Agriculture & Forestry Informations), September 1949.

sufficiency plays in our agriculture.

Poor means of production mean importance of labor on the other hand. Table 1 indicates that this can be observed in the composition of the productive cost. In the prevalence of hand labor of low productivity with poor means of production, the principal part of labor is necessarily constituted by family lobor. It is because the managment must produce labor by itself and also can not afford to hire labor under the condition of such low productivity. It is natural that commercialization of labor can not become common in agriculture as long as self-sufficing agriculture is dominating. In fact, as seen in our agriculture, use of hired labor is confined to the busy farming season. Regular employees are mostly found in the managment of landlord-farmer in such region as Tohoku district (north-eastern section of Japan), but their number is nearly negligible to the total number of workers on farms. The Statistics of Agriculture & Forestry for 1947 shows that the regular farm employees represented a little less than 2% only of the total number of workers on farms (exclusive of extra employees). Consequently, need of labor in the busy farming season is in most cases supplied through the system of the so-called "yui" (interchange of family labor) among farms. Also, actual situation is that, as will be mentioned later, the wages for regular as well as extra employees are paid not only in cash but also partly in kind (especially in meal) — see Table 3 —, which fact indicates realization of self-sufficiency. In the light of this fact, also, our agricultural laborers will not be able to be called laborers in a modern sense. It can be said that they work to get wages as well as to get meals in a direct way. Therefore, as such labor is one to eat, it will be said to have a different element in quality from the modern agriculture labor (commercialized). We see here "not social but isolated labor."[10] Emphasis on spiritual power in working also might be attributed to this very point. It has been often said also that the farm is generally lavishing

labor. But, since farmers are provided only with poor means of production, it would be too natural that application of as much labor as possible should be imperative to secure reproduction. This tendency, needless to say, is even more strengthened by the presence of surplus population. Furthermore, as far as family consumption directly means productive consumption, if only a minor part of family members can contribute to farm labor, extra burden will be placed on them to feed all the family, resulting in heavier labor, as a matter of course.

As discussed in the foregoing paragraphs, for a production with poor means of production and, consequently, relying largely upon labor, the size of management must be very small, because, under such condîtions, the managemnt need not be on a large scale but is required rather in a size proportionate to available family labor. The size of management is, as a rule, determined by the means of production, but in the case of small-sized self-sufficing farm, it is not determined by the means of production but rather by available amount of family labor. Since family labor plays an leading role in the management as a standard, the size of farm naturally is proportionate to the available amount of such labor, but not the means of production. This will be readily observed from the data given in Table 2. Percentage of farms equipped with motors is hghest (more than 40%) for the groups of farms of such size as from 15 to 30 *tan*. The groups of both smaller and larger farms are lower in that percentage. To be more correct, the capacity of the motor will, of course, have to be taken into consideration, too. Neverthless, the number of the motors alone would really serve as an indicator to some extent for the purpose. On the other hand, labor per farm increases generally from smaller to larger farms, except for the 20–25 *tan* farms which show the largest. (The same will be observed also from the data given in Table 4). Of course, the labor does not increase always in direct proportion to the increase in size of farm. This seems to be for the reason that, with increase in size of farm, the portion of the products marketed becomes larger and, consequently, that for farm consumption smaller, while labor productivity becomes higher. At any rate, the reason why our farm management is called a labor management will be readily understood in view of the facts mentioned above. To conclude, productivity of managment is low in the self-sufficing agriculture, and a leading part is played in the management by the family labor rather than the means of production. Therefore, it becomes necessary to analize such management with special attention to labor relations therein. The management of this kind is one of the so-called "Parzellenbauer."

As indicated above, the self-sufficing agriculture necessarily results in small size of farm. Then, it becomes a question whether or not small size of farm, in turn, would always be connected with self-sufficing agriculture. In this connection, it must be considered that productivity is low in the self-sufficing agricul-

Table 2. Percentage of farms with motors and

Size of farm (*tan*)	0–3	3–5	5–10	10–15	15–20
Percentage of farms with motors (%)	7.2	14.7	23.4	35.7	42.4
Amount of labor used per farm (person)	2.0	2.6	3.2	3.7	3.9

Note: Prepared from 24ji Nôrin Tôkei (24th Statistics of regular employees besides family labor.

ture. Therefore, if the small size of farm is combined with low productivity, there will have to be connected self-sufficiency with the small size of farm. With high productivity, however, the small size of farm will not always mean self-sufficing agriculture. Still, because the small size of farm (especially the area of land used for farming) excludes superior means of labor and, in this very sense, the size of farm can be an indicator for productivity, the small size of farm indicates low productivity. That is to say, low productivity and small size of farm are connected with each other. Thus, the small size of farm can be said to have elements which necessarily bring about self-sufficiency in agriculture. More important, however, is the question of relations of production, or type of ownership of farm. In the capitalistic agriculture with productivity of a high level, there can essentially not exist any trace of self-sufficing agriculture, and, consequently, the "Parzellenbauer" in such capitalistic agriculture is considered to be an exceptional existence in a transition period.

What kind of technique is needed, then, by a small-sized self-sufficing farm? It is not a technique of such kind as may serve to raise labor productivity. On the contrary, such technique tends to be excluded from the managment. A small farm as such excludes superior means of labor for the very reason of small size of farm. And also the self-sufficing agriculture as such does not need introduction of means of labor. It is a matter of course that improvement of productivity is indispensable for a self-sufficing agriculture to be developed into a commercial one, and the natural economy to the commercial one, because "the productivity of agricultural labor which runs above the individual need of the laborer is the basis of all the societies."[11] In this case, however, commercial production is only possible if there is production over direct consumption. Therefore, it may be said that only little moment has existed inside the management for development in the direction of commercial production, and rather the influence of commerce has contributed much to such development. At any rate, techniques needed by self-sufficing agriculture must be ones which satisfy the requisite to increase the absolute amount of use value, or the amount of products per unit.

amount of labor used by size of farm

20-25	25-30	30-50	50-100	Over 100	Not tilling	Total
45.9	47.7	37.5	28.2	31.8	5.3	22.1
4.4	4.2	3.9	4.0	4.5	1.6	2.9

Agriculture and Forestry) .. as of August 1, 1947. Labor includes

That emphasis is placed in our agricultural technology on the techniques in the crop improvement, application of manure and fertilizer, etc., which are called the techniques for increasing production, can be explained by the fact that our agriculture is one largely on the self sufficiency basis. Therefore, exclusion of means of labor and, consequently, application of heavier human labor on a small-sized self-sufficing farm is, we must say, the course of nature in order to support the self-sufficing agriculture, or to feed the family.

In conclusion, we can say that, as reproduction in the self-sufficing agriculture is carried out, as a rule, only within the management, it does not need any of new means of production nor new techniques, naturally resulting in farmers' passivism, or even indifference to imporvement of management. This means nothing but to make farm managment and also the farmer himself consevative. Only in commercial production and exchange economy, need for ever-rising productivity and, consequently, interest in new techniques can develop. Self-sufficiency as such, which excludes any new trials, must make the farm management unprogressive and isolated. Conservatism and political indifference of the farmers of this country have resulted from this very point.

V. Double character of natural economy and exchange economy

In the small-sized self-sufficing farm management of Japan, simultaneous presence of money economy and natural economy, as indicated by the above formulas of reproduction, forms a duality of the management. A question arises, then, in what relationship these two elements are in the concrete and what characters they give to the management in actual conditions.

Development of agriculture in a capitalistic society means the rule of capital over agriculture, and an important form of it is observed in the action of capital toward gradual breakdown of natural economy and elimination of self-sufficiency, that is to say, the self-sufficing agriculture is, under the pressure of money economy gradually but steadily developed into a commercial agriculture, and this is indicated by commercialization of agricultural products. In this case, the

agricultural products are forced to be marketed by use of more capital (fund) in the process of production. The character of process of production is directly reflected on the products. The double character of managment can be observed in contradiction of sale and family-consumption (self-sufficiency) in the use of farm products. Table 3 shows the actual situation in this relation on farms in a rice single crop area in Miyagi prefecture.

As the table shows, the portion of rice crop sold increases as the farm becomes larger in size. Consequently, the portion consumed on farm decreases in inverse proportion to the size of farm. On the otherhand, rice consumption per family member averages 1 *koku* 6 *to*, and, though exceptionally large on 15–20 *tan* farms, tends to be generally larger for larger farms. This means that it is parallel with the percentage of commercialization (sale) and reverse to that of farm-consumption. We can see from these data that, as the farm becomes smaller in size, the percentage of farm-consumption increases, and with the increase in the percentage of farm-consumption, the per capital consumption decreases. Of course, small farmers may save their rice by working at daily

Table 3. Distribution among purposes of use of rice

Purpose of use \ Size of farm (*tan*)		Average	40-35	35-30
Farm consumption	Food for family	122.5	158.0	151.0
	Feed	4.7	5.0	—
	Seed	8.6	18.8	18.6
	Sub-total	135.8	181.8	169.6
Sale	Delivery under collection program	245.9	554.0	506.0
	Barter & black market sale	55.5	144.2	164.4
	Donation	3.1	4.0	8.0
	Sub-total	304.5	702.2	678.4
Total		440.3	884.0	848.0
Percentage of sale (%)		62.3	79.4	80.0
Family members per farm (person)		7.7	9.0	9.0
Farm consumption per farm (*to*)		15.9	17.6	16.8
Percentage of black marketing (%)		12.6	16.3	19.3
Labor	Family labor (person)	3.3	2.0	4.0
	Regular employee (〃)	—	3.0	—
	Extra employee (day-person)	36	60	165
Family members who have parttime jobs off own farm (person)		0.5	—	—

Note: Data based on the hearing survey conducted in December 1948 on

wages on other farms. As far as the own products are concerned, however, it is obvious that consumption per family member is small. As to the percentage of black market sale, a general tendency is seen that the percentage increases as the farm becomes larger in size. However, it is lowest for 15–20 *tan* farms and sharply rises again with the farms of less than 15 *tan*. Moreover, trade by barter is done even in the group of the smallest farms of less than 5 *tan*. Here we can see an indication of sale of rice in need of money, or emergency sale, as they call it. This is a result of the pressure of money economy — capital brought upon self-sufficiency, and whether the capital bears hard on the management or, on the contrary, speeds up development of the management will be determined by the character and stage of development of the capitalism concerned. Now, small farmers save their rice by offering themselves for extra part-time job like daily wage earning on other farms, as indicated in the table, and their sale of rice may include such saving of rice. Still, in consideration of the fact that most of the rice-short farmers found especially in the rice single crop areas in the period from rice planting season of May or June to just before the harvest are

produced on farms of various sizes.

30–25	25–20	20–15	15–10	10–5	Under 5
..... (in *to*)					
145.0	191.3	144.0	84.0	62.5	59.8
6.0	2.7	20.0	6.2	—	—
9.6	10.0	6.5	6.4	4.8	1.2
160.6	204.0	170.5	96.6	67.3	61.0
338.0	238.1	268.0	199.1	87.3	—
104.9	35.9	27.5	36.7	13.9	3.0
7.5	2.7	—	2.0	2.5	—
450.4	276.7	295.5	237.8	103.7	3.0
611.0	480.7	466.0	334.4	171.0	64.0
73.7	57.5	63.4	71.1	60.6	4.7
8.0	11.7	7.0	6.0	4.5	6.0
18.1	16.4	20.6	14.0	13.9	10.0
17.2	7.5	5.9	11.0	8.1	4.6
4.5	4.3	4.0	2.5	2.5	2.0
—	—	—	—	—	—
35	63	—	50	3	—
0.5	0.7	—	0.3	1.0	1.0

15 farms at Nigô community, Nangô village, Tôta county, Miyagi prefecture.

such small farmers, the emergency sale of rice will be undeniable.

As indicated above, commercialization of farm products is pushed forward under the burden of the oppressing "Schere" and taxes and other impositions, and thus, the law of value is realized. But since this means reduction of portion of products consumed by farm family, it naturally results in a pressure on the living of farm family. Agricultural panic also is a sort of pressure of capital, and reduced farm incomes resulting from slumped price of farm products bring about sale of larger portion and consumption on farm of smaller portion of such products to a lower living standard, resulting in weakening of self-sufficiency, which constitutes the pillar of the management, and collapse of foundation for reproduction.

Under these circumstances, what can the system of Government collection mean? In the sense that the delivery under the collection program brings cash income to the farmer, it obviously means a sale or commercialization, and may act toward elimination of self-sufficing agriculture. On the other hand, as far as there are given certain fixded quota and official price for the delivery, it may not be thought to be a normal sale of farm products. From the point of view of reproduction, however, it is a problem of circulation of commodities. Now, the reason why farmers have not been always willing to deliver their products under the collection program will lie, besides owing to much higher black market price, in the fact that, from the viewpoint of reproduction, the circulation of G — W — G has often failed to be secured. This is because the productive cost has very often run above the official price. In such a case, the circulation has a difficulty in being realized in the part of money (G). As a result, the deficit will have to be made up for by saving rice for family-consumption and selling it on black market. Furthermore, if the quota itself is unreasonably heavy, it directly forces reduction of family-consumption. In that case, some farmers will be subject to a double burden that they must make up for the deficit resulting from unreasonably low rice price and also are forced to cut family consumption of rice under the direct presuure of the heavy quota

What can introduction of means of production to such small sized self-sufficing farm mean, then? Even if new means of production are successful in raising labor productivity, it does not necessarily mean a gain to the farm management. It is because, though the newly introduced means of production raises labor productivity, without increasing absolute amount of products, they can do noting but provide another pressure upon the family-consumption. Sure, it may be possible that superior means of production can avoid be coming the cause of such disadvantage for the self-sufficing agriculture, yet there is little chance to expect it under actual conditions of "Parzellenagrikultur". Also, unless the newly created surplus labor (It does not bring about elimination

of hired labor but savig of family labor on such farms as in question.) can find any other way to be utilized advantageously (This is the case on most farms.), the cost of purchasing new means of production becomes the burden to be borne by family-consumption alone. Therefore, even though introduction of new techniques can raise labor productivity, unless it succeeds in increasing absolute quantity of products or family-consumption, it comes to suppress the family-consumption which is the real foundation of the farm management and to menace the basic life of the farm family, as a matter of nature. (In this case, the intensity of pressure on the living of farm family depends upon the productivity and utilization of saved labor.) This may explain the fact that most of our farmers are negative to mechanization of agriculture.

To the pressure of capital — effect to increase the extent of commercialization of farm products as described above, what is seen as the resistance of the self-sufficing agriculture ? As regards this point, it can be said that, as far as the capitalism gives a limit to development of self-sufficing agriculture, the surplus population resulting from the present price level of farm products or other effects of the capitalism are supporting the self-sufficing agriculture as such. In this sense, the capitalism not only essentially determines the self-sufficing agriculture but also directly influences it in such a double manner as in the direction of securing and, at the same time, of breaking it down. However, it must be remembered that, although the resistance of the self-sufficing agriculture is essentially to be determined by the capitalism, it presents itself as directed to, or in contrast to, the direct pressure of capital. This resistance is to be observed actually in farmers' adherence to old thing on farms.

The double character of self-sufficiency and exchange characterizes all the Japanese farm managements, as has been made clear in discussions relative to consumption. To proceed further with this question, it will be necessary now to take up the process of production. We have data on the manure and fertilizer, most important means of production, given in Table. 4.

As to the precentage of self-sufficiency of manure and fertilizer in relation to the size of farm, it is found to be in inverse proportion to the size of farm for all of N, P and K, three elements of fertilizer. As for N, it runs up to 50% already for Farm A (70 *tan*), and becomes even higher for Farm B (10.2 *tan*) and Farm C (4.6 *tan*), in the order mentioned. The same will be a fact with P. As regards K, all of those farms show 100% self-sufficiency (probably owing to no Government distribution of the fertilizer of this kind). Viewing this in comparison with the percentage of commercialization of farm products (rice), the higher the percentage of commercialization, the lower that of self-sufficiency of manure and fertilizer, which tendency is the same as observed in Table 3 with regard to self-sufficiency of rice. This indicates that the money (G) is reproduced as such,

Table 4. Self-sufficiency in manure & fertilizer

Farm		Kind of manure & fertilizer			Size of farm (Area of fields)		
		N	P	K	Paddy field	Upland field	Total
		..... (in *Kan*)			..... (in *tan*)		
A	Purchased	83.306	47.406	—	60.5	10.7	71.2
	Farm-produced (Self-sufficed)	85.920	22.925	51.580			
	Total	169.226	70.331	51.580			
	Percentage (%)	50.8	31.3	100.0			
B	Purchased	10.651	5.050	—	9.6	0.6	10.2
	Farm-produced (Self-sufficed)	15.860	6.443	16.120			
	Total	26.511	11.493	16.120			
	Percentage (%)	59.8	56.1	100.00			
C	Purchased	1.042	28.5	—	4.4	0.2	4.6
	Farm-produced (Self-sufficed)	7.286	69.3	1.760			
	Total	8.328	97.8	1.760			
	Percentage (%)	87.5	70.9	100.0			

NOTE: Data based on the hearing survey conducted in January 1949 at

and the matter as such. It must be noted that self-sufficiency prevails irrespective of the size of farm.

As for labor, it goes without saying that family labor is produced from the portion of products used for family-consumption and the money used for housekeeping, and that this is true with almost all of our farms. Realization of self-sufficiency is, however, to be seen not only in the family labor, but also in the hired labor. Table 5 will illustrate it. When we classify 371 towns and villages of Japan according to the type of payment of wages for labor of rice planting, we find that the wage is paid totally in cash only in 23.5% of such towns and villages, and 75.2% of them are those where a part of cash wage is replaced by meals. Especially, offering of 3 meals is most often. Also the compensation for a regular farm emplyee includes not only meals but also other allowances in

Table 5. Classification of towns & villages by type of wage payment.

Types of payment / No. of towns & villages	Cash & 3 meals	Cash & 2 meals	Cash & 1 meals	Cash & 4 meals	Cash only	Cash & kind other than meal	Total of "meal"	Total
No. of towns & villages	110	85	40	24	87	5	279	371
as percentages total (%)	29.6	22.9	10.8	6.5	23.5	1.3	75.2	100.0

NOTE: Data from the report on wages for rice planting labor in 1948 published in Nôrin Chingin Geppô No. 3 (Monthly report on wages in agriculture and forestry No. 3).

on farms of various sizes.

Large animals		Commercialization percentage of products	Number of family members	Number of regular employees	Total rice Crop per	Rice yield *tan*
Horse	Cattle	.....(%).....			.... (in *koku*)	
1	2	83.7	8	5	160.0	2.65
—	1	61.5	5	—	32.0	3.14
—	—	48.0	5	—	11.5	2 62

Tsutsumine community, Takakura village, Shida county, Miyagi prefecture.

kind in most cases.

The above illustrates that self-sufficiency puts in its appearance in both the means of production and labor. In view of this fact, we can say that the self-sufficing agriculture is to be seen not only in the rice single crop areas but also the upland field areas and even the vegetables and fruits areas comparatively highly commercialized.

Even the farmers of upland field areas who grow no rice are doing trade of products of upland fields such as soybean, potato, etc. by barter.[12] (The barter trade may be regarded as a sort of sale, but noteworthy is that it is still not a normal type of sale. As far as it is done for the purpose of avoiding the expenses of circulation, it bears the character of self-sufficiency. The reason why almost all farmers prefer payment in kind to that in cash might lie in this point.) As described above, there can be no farm management without self-sufficiency in Japan, and therefore, more or less rice is grown even on the farms in mountain or remote areas. It has been often said that rice has absolute position to the geographical conditions of Japan. However, understanding in this connection can not be said satisfactory if one fails to recognize not only the high and stable yield of rice, but also its importance as staple food for farm family. The fact that, despite the productive cost of rice on most farms going above the ceiling price which is always set at a low level, cultivation of rice still has not been abondoned is considered to be attributed not only to relative advantage of

growing rice compared to other crops, but also to the indispensability of rice as food to the life of farm family. In such case, it might be said that "the farmer becomes merchant and industrial without the conditions under which he can produce his product as commodity."(13) also, it is important that the capitalism works to break down the self-sufficing agriculture and, at the same time, to support it. This will be indicated by the adverse flow of population from the urban areas to the farms, which will need no illustration. It is on account of this effect of the capitalism that the self-sufficing agriculture constitutes still now the substantial part of our farm management and self-sufficiency prevails in every aspect of the farm management.

To be brief, it is not too much to say that self-sufficiency in the farm management serves as a passive safety valve of the management bearing the pressure of the money economy practised in the same management. It may be the real state of our farms that they are repeatedly driven back to old practices by the blow given on the part of the management practising money economy. In such management, the farmer never stops production as long as he can get something equivalent to the wages of his own and his family, no ! production is continued even with the living standard of family lowered to a lowest tolerable point. This leads to the conclusion that it is not the commercial agriculture but self-sufficing agriculture which constitutes the foundation for our agricultural production.

The farm management in Japan stands on such contradiction between the natural economy and commercial economy as indicated previously. The capitalism not only determines essentially the double character of the farm management, but also constantly works so as to break the self-sufficing agriculture as a necessary effect of the capital, and, on the other hand, the self-sufficing agriculture presents itself as a resistance to the direct pressure of the capital. To the question on which of them the farm management standing on the contradiction between the above two elements is based more essentially, we shall have to answer that it is founded essentially on the natural economy. Discussion has not been made enough in this relation. However, it will be enough to point out the fact that there can be found those farms on which production is carried out exclusively on the basis of the natural economy, but that it is hardly possible to find out such farms as are based perfectly on the exchange economy and involve no trace of the natural economy in Japan.

The capitalism in this country has changed from time to time the type of its rule over agriculture according to the stage of its development. It may be said that commercialization of farm products is gradually increasing in extent though the self-sufficing agriculture still survives. It can be said, however, that essential determinants in the rule of the capitalism over agriculture have not been changed yet. Consequently, it is still unchanged that the self-sufficing agriculture forms

the keynote of Japan's agriculture, and that the natural economy forms the essential character of the farm management. The conflicting two elements in the double character of management have been under interaction, and the management has been constantly standing on such contradiction. The farm management has been under constant drive to develop, although it involves no moment for development. Here might lie the real agony of the farm management, and, consequently, of the farmer. To be particular, the self-sufficing agriculture is, on one hand, under the direct pressure of capital which works so as to break it, and, on the other hand, under the essential influences of capital which support and keep it back. Such dilemma of the self-sufficing agriculture menas the dilemma of farmers who support their lives on the self-sufficing agriculture.

VI. Conclusion

It has been already mentioned that, though the farm management in Japan stands on the contradiction between the natural economy and exchange economy, it is more essentially based on the former.

The natural economy is characterized by the consumption directly turned into production and the reproduction carried out only within the management. As a result, the management becomes isolated and unprogressive in character and excludes superior means of production. It involves, by nature, no element inside which may raise labor productivity and modernize the management. Whether, in this case, the process of breakdown of the natural economy under the pressure of capital proceeds without troubles or not depends on the character of the capitalism itself. In Japan, this process produces such effect as to support the natural economy on which reproduction in the farm management is based, on one hand, and suppresses it, on the other hand, consequently, not only preventing the farm management from developing into modern one, but also menacing even the farmer's life and setting it on an unstable basis. The pressure of capital might have given farmers the same impressions as the agricultural damages, which have occurred very often in recent years, as far as they deprive them of the basis of the natural economy.

Under circumstances, what could be successfully done to improve Japan's farm management? First, the following may be said from the standpoint advocating development of the commercial agriculture. Expansion of the extent of the exchange economy means, indeed, a step forward for the farm management in present day Japan. Yet, it is very questionable if this is possible under the objective conditions under which the Japanese captialism of the day is placed. as previously indicated. Now that the farm management itself hardly involves inside any moment to develop it to a modern standard, if our farm management is to be developed, the character of the capitalism itself must be changed. Unless

the productive price of farm products is realized and the surplus population on farms absorbed, development of farm management is hardly possible. We can say that it is an indispensable condition for such development that the part of the farm management practising the exchange economy at least stops becoming a burden and pressure on the part of the farm management based on the natural economy. Although semi-feudal landlordistic landownership has been weakened to some extent, we must say, as long as the above conditions of the capitalism exist, the self-sufficing agriculture continues to form the essential part of the farm management, and there is a long way for the Japanese farm management to go to reach the modern standard.

What can it mean, then, to emphasize the self-sufficing agriculture, or self-sufficiency, for improvement of farm management? Arguments emphasizing the self-sufficing agriculture have as their real basis the actual survival of the self-sufficing agriculture which should be but could not be developed into a commercial agriculture and dissolved as shuch. However, as far as the causes for the difficulties confronting the farm management lie outside, but not inside, the farm management, it can not be a help to solution of the problem to emphasize self-sufficiency, because it means a trial to turn social economic causes into the question of individual farm management and to solve the problem as one inside the management. In general, self-sufficiency makes the management conservative and unporgressive, but never encourages its development. We must say, therefore, that to emphasize the self-sufficing agriculture is nothing but to turn social causes to the responsibility of the individual. The self-rehabilitation movements advocated in the years of the agricultural panic of early Showa seem to have been in favor of this policy. However, even if the self-suffiicing agriculture contributes nothing to development of the farm management, it can be said that, since the farm management of the present-day is carrying on farming to feed the farm family, the self-sufficing agriculture do have some reason for existence in relation to the efforts to improve the management to a point where the family can be fed any better. In fact, it is because the farmer has the self-sufficing agriculture in his farm management that he can resist, though passively, to the pressure of capital and maintain his life. In this sense, we must say that the self-sufficing agriculture serves as a safety valve for the farm management of the present time and provides the basis for the farmer's life. If it can, however, neither develop the farm nor improve the farm management, consequently, nor raise the living standard of the farmer, emphasis on the self-sufficing agriculture will succeed at most just in maintaining the status quo.

What can be the actual course of development of the small self-sufficing farm management? In view of the simultaneous presence of the exchange economy and natural economy within a management, as long as they contradict to each

other, rationality from one viewpoint will naturally be irrationality from the other. Rationality in the commercial agriculture means to raise labor productivity, or, more concretely, to introduce superior means of production including machinery. On the other hand, the self-sufficing agriculture usually does not need any introduction of farm machines or any other means of production of this kind, or even excludes them, because they may bring about surplus labor on farm and menace the basis of farmer's life.

As previously indicated, however, it is under specific conditions of the capitalism that development of labor productivity drives the management into difficulties. This can not be the case under a normally developed capitalism. It is, therefore, a basic pre-requisite for higher productivity of agriculture and progressing farm management to lead the capitalism to the normal course of its development. If it is accomplished, introduction of machines will by no means result in a pressure upon the self-sufficing agriculture, and the agriculture of this kind is expected then to turn toward natural dissolution. And thus, development of farm management on a natural course will be accomplished.

If the capitalism fails to be developed in such manner as mentioned above, what will be left to be done, then ?

First, attention may be called to reduction or elimination of the direct pressure of capital, such as "Schere", taxes, etc. But this is essentially under the same conditions as the above. The way of accomplishing progress of agriculture is, in the above case, to normalize the factors essentially determining the self-sufficing agriculture, i.e. the character of the capitalism, and, in this case, to minimize the effects of capital acting toward dissolution of the self-sufficing agriculture. These two things, however, represent just two different aspects of the self-contradiction which the capitalism involves. They, of course, originate from one thing.

Accepting the above conditions of the capitalism as given, the only way left then is to try to solve the problem as one of the farm management itself.

In this case, independent rationalization of each of the natural and money economies is impossible, as long as these two are under contradiction to each other. Any such trial may aggravate the situation by obstructing even more the progress of the farm management. It is, therefore, obviously unreasonable under such conditions to emphasize the self-sufficing agriculture independently. It may be, indeed, a means of avoiding the pressure of capital for a farmer to consolidate the system of self-sufficiency and entrench himself in the natural economy. But in the present capitalistic society, there can be no life based entirely on the natural economy, and it is also clear that such life is not desirable. In fact, most self-sufficing farmers are compelled to earn money from jobs off their own farms : 84.6% of the farmers with less than 10 *tan* of land had such jobs in 1947, as

statistics show. Still, it is also true that most farmers find the basis and stability of their livelihood in the self-sufficing agriculture. This is against the social rationality, and makes the farm management conservative and unprogressivd, providing the ground for the feudalistic character of the farm. It is evident, after all, that development of farm management can not be realized by any means but taking the course in which unification of the two conflicting factors may be accomplished. What is it, then ? It is to increase the element common between the natural and exchange economies, or use value — absolute amount of production per unit, though this increase in absolute production must not conflict with that of labor productivity. This naturally means the course of the commercial agriculture. It must be done, how difficult it may be, to find out a means which is adapted to the actual situation of the small farm management and also satisfies the above conditions. In this case, the stronger the pressure of capital is, the more difficult the work will be.

The farm management in Japan has been under contradiction between the natural economy and exchange economy, though essentially based on the former. Many trials have been made to improve the farm management, but is seems that more efforts have been directed in most of such trials toward change of type of farm management rather than increase of the size of farm. This meant a trial of distributing risk, and, as such, may be said to have reasons. But the efforts of this kind succeeded, in most cases, only in intensifying self-sufficiency, but not in developing the farm management as a whole. Of course, development of farm management can not be expected with the self-sufficing agriculture. But also many trials to encourage commercial production on farm have failed to accomplish improvement of farm management. Such failure may be attributed to promotion of commercial production without taking into account the double character of the farm management. Improvement of the small self-sufficing farm management needs increase in absolute amount of production as well as in labor productivity, as far as the course of commercial agriculture is followed. What can this be in actual conditions of the farm management ? It is to increase the size of farm rather than to diversify the farm by introducing new crops, livestock, or the like. If increase in the size of farm is impossible, there will be a need for development of cooperative activities.

At any rate, the problem of the self-sufficing agriculture is one of the dark side of Japan's agriculture. It seems that improvement of farm management and development of agriculture as a whole in Japan can not be accomplished without making clear this point.

Summary

About half of Japanese famers is self-sufficing farmers and nearly half of farm products (rice) is comsumed by them. From a standpoint of the reproduction of farm management we understand these facts as a double character of money economy and natural economy. The double character of Japanese farm management and the distinction as a result of it are attributed to the following reason. the circulation of matter within the management is due to the fact that the use value of productive means and labour is equal to that of products and that the farm management can not bear the cost of circulation on account the low labour productivity.

The double character of farm management is determined by the character of capitalism ; the capitalism supports the natural economy on the one hand and breaks it on the other hand. The double chracter is also determined by the character of farm management itself such as the type and size of farm.

The circulation of matter within the management gives the following character to it. Namely the consumption of products by farmers becomes at once the productive consumption, and it appears the inseparablity of farm management and housekeeping.

So the farmer must utilize all the consumed matter as well as the labour of old men, children and women for the production, and moreover the night soil must be used for the reproduction. In such farm management the farmer is not in need of superior productive equipments, and the production is carried mainly by hand labor. The farm management in this country is thus small and can not introduce any better technic easily.

Japanese farm management has the double character of the circulation of matter and money, but the natural economy is always under the pressure of the money economy. The base of the Japanese farm production is the self-sufficing agriculture to eat and not the marketing agriculture to sale. Thus the improvement of the Japanese farm management can not be introduced only by the technic which raises the labor productivity.

Literature cited

(1) K. Marx, *Das Kapital*, Vol. I, 1st Ed., Moscow (1932), 593.
(2) K. Marx, a.a.o. Bd. III/2, 846.
(3) K. Marx, a.a.o. Bd. III/2, 838.
(4) K. Marx, a.a.o. Bd. III/2, 662.
(5) K. Marx, a.a.o. Bd. I, 599.
(6) K. Marx, a.a.o. Bd. III/2, 836.
(7) B. Raihart, *Economic Thesis on precapitalistic formation of Society*, (translated into Japanese by M. Nagasumi) 1st Ed., Tokyo (1936), 329.

(8) B. Raihart, ibid, 390.
(9) B. Raihart, ibid, 339.
(10) K. Marx, a.a.o. Bd. III/2, 865.
(11) K. Marx, a.a.o. Bd. III/2, 836.
(12) M. Yamagishi, Tohoku Nogyo (in Japanese), **2** (1949).
(13) K. Marx, a.a.o. Bd. III/2, 864.

A Consideration on the Characteristics of Farm Book-Keeping*

Mitsuo ONODERA

(Received November 1, 1951)

I. Introduction

The circulation of the capital in the agricultural management which is carried on as an enterprise in which include a productive process which will produce suplus value takes the form of the capital in individual industry. In order to grasp the circulation of the capital from the standpoint of value, the direct application of the industrial book-keeping, which has made progress with the development of industry, should be made to it.

The dominant form of farm management in Japan is still on a small scale, in which labor of the family hands is most important; it has not developped to a complete capitalistic industry, keeping with it the elements of natural economy. It exists whith the characteristics of both the exchange economy and natural economy.

It gradually takes the form of market economy, and for this reason, it can be grasped by means of industrial book-keeping. In doing so if we grasp only the scope which belongs to the exchange economy, it will not be a complete understanding of the agricultural economy, because we cannot do away with the field of natural economy as an object of book-keeping in the sense that it maintains the agricultural economy and continues its reproduction. It is for this reason that the fectitious evaluation becomes necessary in the accounting of the agricultural economy. In other words, anything which has not passed the stage of commodity should be conceived as having any value from the standpoint of book-keeping. It must be determined to what category it belongs in book-keeping, and its value must be evaluated. The agricultural book-keeping comes into existence in response to the necessity of utilizing the principles of book-keeping, which should be commercial in nature, in the unterstanding of the farm economy. The farm book-keeping under discussion aimes at the grasp of the circulation of capital in the small-scale farm as an individual economy unit during a definite period of time and in farm of accounts in the book. Moreover, in this

* The 65th report of the Institute for Agricultural Research, Tohoku University (1951).

consideration, the production and consumption of the farm goods will be studied as the conditions indispensable in making the circulation of capital in farm economy.

Needless to say, the methods of recording the circulation of capital in value can be classified in two systems, namely, single entry and double entry. The single entry has no capital accounts, keepng in books only assets and debts; therefore, it cannot make clear the causes for and the contents of profit and loss, though it may ascertain the net prafit and loss during a definite period of time. On the other hand, the double entry makes it possible to keep the record of variations in property, and to know the causes of profit or loss, by keeping and calculating, with certain rules of keeping books, the variation of assets, debts, variations of capital, expense and causes of profit or loss; it also has means to check the entry and calculation. Therefore, we must utilize the double entry system in order to grasp the capital in the management in the value volume.

In order to grasp the value motion in the small scale farm, which has a form of motion different from the individual industrial capital, though they are enterprises themselves, from the standpoint of the double entry system, which form will be most proper? It is the aim of the present paper to study of the form of book-keeping applied to grasp the characteristics of the capital circulation in the farm economy.

II. The Characteristics of Agricultural Capital

1. The dominant management form in our farming is the small scale management. Here employed labor is utilized when it is necessary to replenish that of the family hands. If his farm cannot support his family, he goes out to earn wage or run some small-scale management other than farming. The farm management consists of self-supplied labor and "distributed various means of production which are helpful as means of maintaining livelihood"(1), but, essentially, it is not the capital. Essentially, they are not a commodities, because the farm products are consumed by the farmers themselves.

Although there is no capital in the small scale agriculture in the true sense of the word, we should bring it into question when we discuss the agricultural capital from the standpoint of book-keeping. We cannot undertand it economically, unless we grasp in the economic activities of the small-scale farm and analyse it as the movement of the productive capital. The agricultural capital, as we understant it, is of such a nature. The difficulties we meet in grasping the agricultural book-keeping, in contrast to commercial and industrial book-keeping, is to be found in many fictitious valuations made in calculation.

2. When we see the circulation of the capital in the farm management in Japan from the view-point of money capital, we at once recognize the process G — W, namely, the process through which money passes as a measures to buy

a means of production and labor. Affter passing through further process

$$W<\overset{P_m}{A}\cdots\cdots P\cdots\cdots W,$$

it is transformed to new commodities W′. The comodities thus produced will be sold in exchange for G′, that is, at the end of the process G′, it will produce surplus value. The Agricultural capital has the same characteristics as the industrial capital and it is natural that it should include the productive process in its circulation, but this is not the whole story, and the circulation formula for the capital in small agricultural economy has another peculiar phase. The above circulation is that of the capital in the commodity economy, but the agricultural economy has another capital circulation, which cannot be disregarded in the book-keeping. For example, as shown in Table 1, the ratio of the intermediate products to the movable properties in the farm-household properties is 11.3% per farm with less than one "*cho bu*" of land, but it increases with the increase in cultivating land and is 28.6% per farm with more than three "*cho bn*" of land, showing an average of 17.9%. Moreover the ratio occupied by the intermediate products in the increment of the current assets is given in Table

Table 1. Ratio of intermediate product to movable goods.

Size of farms	Movable goods (A)	Intermediate product (B)	B/A (%)
1cho and less	Yen 23,309,46	Yen 2,634,05	11.3
1∼1.5	28,172,28	4,300,84	15.3
1.5∼2	34,690,19	6,664,05	19.2
2∼3	39,105,63	8,264,67	21.1
3∼	45,336,40	12,959,71	28.6
Average	31,829,67	5,708,39	17.9

Adapted from Statistics and Research Division, Ministry of Agriculture and Forestry, Report of Farm-Household Economy Survey, 1947.

Table 2. Ratio of intermediate prduct to increment of current asset.

Size of farms	Current asset (A)	Intermediate product (B)	A/B (%)
1cho and less	Yen 12,457,62	Yen 2,677,70	21.5
1∼1.5	13,887,62	2,034,17	14.6
1.5∼2	12,675,83	1,284,20	10.1
2∼3	15,318,18	2,083,97	13.6
3∼	25,248,84	2,969,28	11.8
Average	14,206,25	2,057,40	14.5

Adapted from Statistics and Research Division, Ministry of Agriculture and Forestry, ibid.

2, showing it to be more than 10% even among the lowest class of farm with one "*cho*" five "*tan*" to two "*cho*" of land, the maximum being 21.5% for the farm with less than one "*cho*" of land.

When we look at the ratio of the products consumed at home and those given away in barter, we find that the highest ratio in the home-consumed products is 46.1% for the farm with less than one "*cho*", which is more than half of the family expense and that the lowest ratio is 38.0% for the farm with 1.5 to 2 "*cho*" of land, the average being 40.3%. The ratio of the expense from the home-consumed products given away in barter to the family expense is less than 4.0%.

Table 3. Ratio of home-consumed products and those given away in barter to household expenditure.

Size of farms	Household expenditure (A)	Home-consumed product (B)	Home-consumed product given away in barter (C)	B/A (%)	A/C (%)
1cho and less	Yen 59,823.50	Yen 27,570.34	1,936.82	46.1	3.2
1~1.5	74,109.02	31,310.92	1,455.14	42.2	2.0
1.5~2	87,909.44	33,364.25	3,373.15	38.0	3.8
2~3	91,382.88	35,239.81	2,086.69	38.6	2.3
3~	105,301.50	41,852.31	4,161.63	40.1	4.0
Average	79,584.18	32,069.29	2,247.62	40.3	2.8

Adapted from Statistics and Research Division, Ministry of Agriculture and Forestry, ibid.

Thus, the circulation of agricultural capital, the production of self-supplied use value which occupies a great ratio in the economic activities of small farm management, may be expressed.(2)

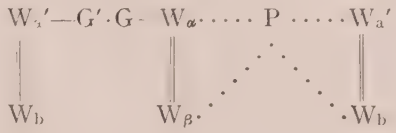
$$G - W_\alpha \begin{cases} P_m \\ A \end{cases} \cdots\cdots P \cdots\cdots W_\alpha' - G'$$

$$W_\beta \begin{cases} P_m' \\ A' \end{cases} \qquad W_b$$

In the small-scale farming the commodities are produced not only by the productive means P_m and labor A bought by money, but by the products produced but not sold, that is, by the utilization of products unrealized and the self-supplied labor. The new use-value, produced by the productive mean and labor either purchased or self-supplied, is the commodities W_α and W_b which will be used as self-supplied goods. Thus, we must study W_β and W_b in order to grasp the characteristics of the value circulation in small farm economy in distinction to pure capital in industry.

Different from the formulas for money capital and productive capital, the

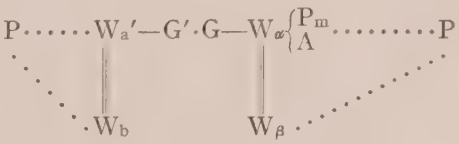
formula of the circulation of commodity capital is at its initial point an uncreament value W′, so the above forumula must be grasped in the form $W_a' - G'$, $G - W_a \ldots . P \ldots . W_a'$. Consequently the form of the circulation of W_β and W_b should be considered from this viewpoint, and it is proper to make an increment value the initial point. In this way, the form of the circulation of commodity capital and self-supplied products will be



Now we shall look into the nature of W_b as the initial point and how it changes into W_β.

Both W_a and W_b are the products of small scale farm economy, and from the viewpoint of their use value, they cannot be separated from each other in accordance with a certain standard. For example, such product as seed can be sold as commodity or may be utilized as a means to the production for the following year. The fundamental difference is to be found in that the value of W_a is realized through sale, whereas W_b is not put on market. In other wards, W_a is the product not yet sold, and W_b is the product not for the market. The former will have its value when sold, and the latter is utilized as use-value in production and in home consumption.

As regards the form of the productive capital in small farm economy, we can put it as



and its circulation will not come to an end at the ending point ; independent of the will of the capitalist, the capital makes the exchange point the initial point of another circulation. Thus, the capital in the small farm management has the character of the industrial capital that the maintenance and continuance of reproduction is the first condition of the circulation movement.

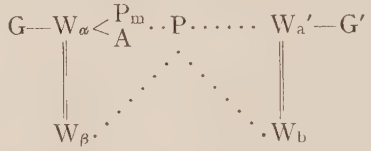
III. Characteristics of Agricultural Book-keeping

1. The agricultural book-keeping is one system of book-keeping classified in accordance with the object it aims at like commercial and industrial book-keeping. It has for its object the circulation process of the industrial capital

$G—W\begin{cases}P_m \\ A\end{cases}\cdots P\cdots W'—G'$, but the characteristic which distinguish it from the commercial and industrial book-keeping is to be found in that it deals with not only the pure movement of the capital.

Let us consider here the movement form of some peculiar capital in the farm management, from the standpoint of book-keeping. The relation between the enterprise and management, both of which are the objects of the book-keeping, is to be found in the fact that "the productive process of commodity is the unification of the labor process and value-forming process, as the commodity is the unification of the use-value and the value."(5)

Therefore, the object of the agricultural accounting will be



Moreover, we cannot disregard, in calculation, W_β and W_b for the reason that they do not pass through the circulation process. The value-part played by W_β W_b in the small farm economy is that they have greater ratio in the small agricultural management and that they are naturally connected with other productive factors of the small farm management.

2. How the value of a commodity is formed may be expressed by C+V+M, and this is true not only of the commodity but of the enterprise that is, "it is the financial report of income and expenditure simplified. The total value is equal to the total income accruing from the sale, the invariable capital to the expenditure for materials and depreciation funds, the variable capital to the expenditure for the salary, and the surplus value to the income distributed as interest and dividend and that available for reinvestment"(4); V+M represents the new value formed by labor. Consequently, C+V+M can be expressed C+(V+M), from the standpoint of its formation, but from the viewpoint of the capitalist, C+V is what he actually spends as expenditure, therefore, C+V+M is expressed as (C+V)+M, not as C+(V+M). Thus, what is important to the capitalist is not the surplus rate, the relation between M and V, but the profit rate, the relation between M and C+V. Therefore, the rationality of an enterprise to the capitalist is the high standard of profit rate. And so, the chief ends of the book-keeping is the means to the high profit rate by making clear the results of each business year; calculating the profit rate as accurately as possible and obtaining data for higher profit.

As the value shows itself as prices in the circulation, the calculation of the value must be made by the calculation of prices. Therefore, the chief end of the

book-keeping is to be found in the calculation of the result of a given business year expressed in prices. There are two methods for such a calculation as shown in the following table.

Any increase or decrease in the capital made during a given business can be determined by an inventory or a balance sheet made either at the beginning or the end of that business year. It can make clear the increase or decrease of the capital, but it cannot make clear the cause or process how such an increase or decrease will occur. This is the reason why the calculation of loss and profit becomes necessary. The characteristic of the double entry book-keeping is to be found in its self-checking function which enables men to do property calculation and loss and profit calculation at the same time and continuously.

3. Naturally a small farmer "can be regarded first as the employer (the capitalist) who uses himself as the laborer, or as the landowner himself who uses his own land as the tenant farmer, if he works for himself and sell his own products. He pays the wage to himself as a wage earner, claims profit for himself as the capitalist and pays the rent to himself as the landowner."(5) In reality, however, he obtains only one income, not receiving the wage, profit and rent separately as such. The small farmer is a wage earner in the sense that he works himself in order to obtain his livelihood, and a capitalist in the sense that he owns the means of production that he uses.

In order to grasp rather complicated contents of the agricultural income as compared with that of individual enterprise, the Kyoto University System has been used as shown in the following table.

In the table, the formulas (1) to (4) are what are called the dynamic calculation, corresponding to the loss and profit calcuation, and the formula (5) is the static calculation, corresponding to the property calculation. Such a book-keeping system as this may be said to possess the self-checking function by saying that

Table 4. Two kinds of method for culculating business result.

(A) Calculation of assets

(1) Assets at the bigining of the financial year−liabilities at the bigining of the financial year=capital at the bigining of the financial year

(2) Assets at the end of the financial year−liabilities at the end of the financial year=capital at the end of the financial year

(3) Profit and loss for the financial year

(a) Capital at the end of the financial year−capital at the bigining of the financial year net profit

(b) Capital at the bigining of the financial year−capital at the end of the financial year=pure loss

(B) Calculation of profit and loss

(a) Total profit−total loss=pure profit for the financial year

(b) Total loss−total profit=pure loss for the financial year

Table 5. Method for calculating the surplus of the farm-household.

Gross income=agricultural income+non-agricultural income+increase in value of fixed assets+increase in value of liquid assets	(1)
Gross expenditures=agricultural expenditure+non-agricultural expenditure+taxes, public imposts and charges+depreciation expense of fixed assets+depreciation expense of liquid assets	(2)
Income of farm-household=total income−total expenditures	(3)
Surplus of farm-household=income of farm-household−household expenditure	(4)
Increase in value of farm-household assets=assets at the end of the financial year−assets at the bigining of the financial year	(5)
Surplus of farm-household=increase in value of farm-household	(6)
Increase in value of farm-household−surplus of farm-household=0	(7)

the surplus of the farm-household economy calculated by the former method is equal to the net increase of the agricultural property resulted from the latter method.

As Prof. Otsuki said, this system has been built "on the application of the principles of double entry to the recording and calculation of the small farm economy in our country"[6], but whether this system is proper or not in recording and calculating the small farm economy should be examined.

4. In a small farm economy, there exists no capital, in the proper sense of the word, because it is not an economic unit which aims at the formation of the surplus value through employed labor, though we find it something like a capital. The small farm management is not capitalistic fundamentally; it has many self-sufficient characters. The book-keeping, which has been developed as that of the modern enterprise and aims to grasp the capital quantitatively in its circulation process, must make fictitious valuations extensively in calculating quantitatively the small farm economy.

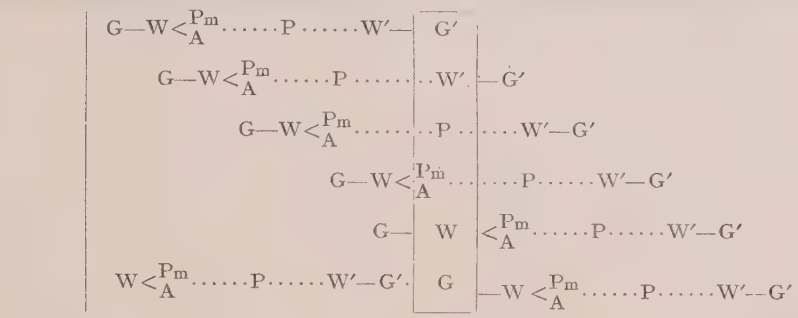
In order to grasp, as a whole, the economic activities of the farmer which are entering the commodity economy, we must depend upon double entry as a means of calculation. In utilizing it we make many fectitious valuations which is the basic cause for making the records and calculation unclear.

For a concrete example, let us take the case of making up a balance sheet, which is the last process of calculation in the book-keeping. In making up a balance sheet, we must grasp definitely the amount of property at the given time. In the farm book-keeping, it is necessary to do extensive valuations than in the industrial book-keeping.

How to take hold of the capital in circulation at a given time may be expressed by the following formulas.

Thus, the capital in circulation taken hold of at a given time B will be as follows ;[7]

Table 6.



Dr.	Cr.
G+Pm+A+P+W'+G'	ΣG+g

In the above case, it is possible to calculate P_m in the same way as A, though it entails a certain degree of difficulty from the view point of calculating the expenditure for a budgetary. Consequently, we can properly evaluate the goods which will be produced with the expenditure to be spent.

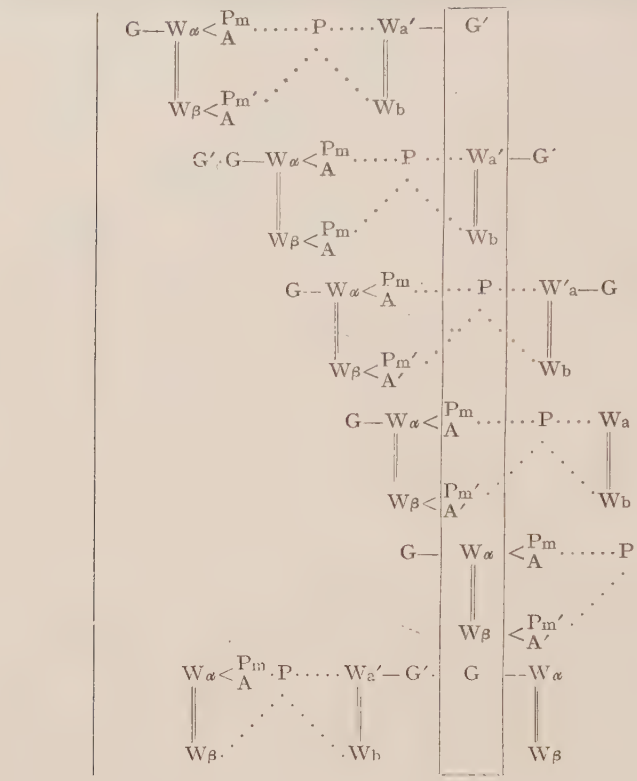
How to grasp the capital in circulation of the small farm economy may be expressed by the following formula in the Table 7 :

The balance sheet will be as follows :

In comparison with the example mentioned above, it has P_m, A' and W_b over and above other items, therefore, it leaves much room for aptional elements in the calculation. This is due to the fact that the self-sufficient element is attached to the capital circulation, especially the greater part of the used labor is occupied by the self-supplied labor, which cannot be neglected in the calculation.

Difficulties do not end here ; there are some external causes. In the case of the small farm management, the price of the farm product is subject to the law of value, realizing no average profit ; it is always subject to an abnormal law of value. In addition, in combination with other side business, its expenditure price cannot be realized. The agricultural income tends to become below the wage level, that is, W in W'(W+w)−G'(G+g) will not be g, and W cannot always be realized easily. From the standpoint of book-keeping, it would lessen the significance of we calculate W' as W+w in order to grasp such a value. In the agricultural book-keeping, the part played by the calculation of the cost of production is less than that played by the cost accounting in the inducstrial book-

Table 7.



Dr.	Cr.
G+Pm+A+Pm′+A′+P +Wa′+Wb′+G′	Σ G+g

keeping. Nevertheless, we cannot say that the part played by the calculation of productive cost and that of the departmental cost are less than that played for other industries.

IV. Evaluation of Self-Supplied Products

1. How can we overcome the difficulties that stand in the way of introducing the industrial book-keeping to the small farm economy and can we make it appropriate ? What gave rise to questions in the farm book-keeping was the natural

economic scope, namely, the self-supplied phase. It is the question of how to consider $W<\frac{P_m'}{A'}$ and W_b. We shall discuss here self-suplied articles other than the self-supplied labor with the table given above, leaving the latter far a discussion in the later section.

We can calculate the result of the farm management, neglecting the self-supplied elements in the calculation. If we put them in the calculation, the field where we shall have to make fectitious valuation becomes extensive. Consequently, there are some who say that it will be satisfactory to grasp the field which goes through the circulation because of the arbitrary elements in the calculation.

In his "Agricultural Book-keeping", Prof. Yasuo Kondo says, "So long as the book-keeping remains as a means to see the comprehensive result of the farm economy, it can achieve its end by calculating only the cash income and expenditure"(8). Further, there are some who try to introduce the theory that good can be excluded from the calculation not only into the calculation of the comprehensive result but also into the calculation of the productive cost. Prof. Wasaburo Kimura insists, "In order to calculate the productive cost of rice produced under the existing conditions in our farm management, we should not discriminate between the household economy and agricultural expenditure, but differentiate goods economy from money economy. It is the concrete and realistic way of calculation to grasp all the productive cost and expenditure at the initial state of case expenditure, avoiding as far as possible the technique of calculation to do evaluation in the calculation of the productive cost".(9)

If the self-supplied elements are constant, that is, $W_\beta=W_b$, either the increase or decrease in the capital as the comprehensive result of an economic activity can be determined by a numerical grasp of the commodity phase of that economy. On the contrary, when the self-supplied articles as productive factors are either greater or less than the articles produced in value, that is, $W_\beta>W_b$ or $W_\beta<W_b$, the result of the management cannot be determined without taking into consideration the self-supplied elements.

2. How shall we go about grasping the self-supplied elements in calculation? Anything in the farm economy which can be treated as valuables in book-keeping should have a price. Even if it has no price now, it shoud be something which can have the price in the future. In other words, self-supplied articles as they may be, they should be made objects of exchange socially. W_β consists of intermediate products and self-supplied labor and W_b of intermediate products and home-consumed goods, but here the intermediate products are considered as simple valuable goods.

In order to grasp the farm economy as a whole by the book-keeping of double entry, we should establish title of account for each process by which the intermediate products change their forms, and continue the calculations. In such

a case, to what extend the actual good should be itemized may be determined by the concrete aim of the book-keeping. Needless to say, the calculation of such intermediate products belong to that of assets. For example, manure put in use in the rice field may be itemized, Dr.: Rice Account; Cr.: Manure acount.

It is proper to do calculations by such a method when accurate calculation and at the same time the calculation of productive cost and departmental caculations are to be done, but is not there any simpler way of calculation, when the calculation of comprehensive result of a farm for a certain period of time is desired ?

In the investigations made by the Ministry of Agriculture and Forestry since 1921 on the farm economy, several revisions have been made as to the treatment of the intermediate products. We shall consider the question from the viewpoint of such revisions. In respect to whether the increase or decrease in the intermediate products should be put in the calculation to be done at the end of each fiscal year the investigations done for the years from 1921 to 1923 did not put them in the calculation of the total income and expenditure of the agricultural management. The investigations for the years from 1924 to 1930 put them in the calculation as income and expenditure. Since 1931, they have not been calculated and both the income and expenditure have been excluded from the calculation. Furthermore, "The investigations have been continued since 1942 but their reports contain no calculation of the productive cost and consumption price of the intermediate products. But for those intermediate products which are actually on the spot at the end and the beginning of the fiscal year, the increment value, obtained by substracting the value at the beginning of the fiscal year from that at the end of the fiscal year which had been calculated with the market price such as constituent price, has been calculated in the increase or decrease in the actual goods".[10] Thus, how to deal with the intermediate products had been simplified step by step until 1948 when the calculation for them was entirely done away with. According to the farm-household economy survey by the Ministry of Agriculture and Forestry, for those intermediate products actually on the spot at the beginning of the fiscal year, the value calculated from the market price was put in the calculation, but it was appropriated not put the balance of increase over decrease for this fiscal year, because the same value is considered to be there at the end of the same fiscal year[11]".

The reasons for such changes in the treatment of the intermediate products given by the Ministry of Agriculture and Forestry in its survey for 1941 as follows: "At first sight, the intermediate products seen very simple, but, in fact it is quite contrary. They are unclear and complicated. If they are to be calculated, they show themselves in different farms repeatedly in the calculation. Therefore, it is difficult to keep them in books correctly. Moreover, it makes no difference to the calculation of the farm income whether they are included or not.

For this reason, it has been decided not to calculate them in view of the great increase in the number of farm houses to be investigated".

To be sure, it may be accompanied with much difficulty and it may be difficult to evaluate them. Consequently, it is difficult to keep the exactness in calculation. But we cannot agree with those who say, that the exclusion of these elements from the income and expenditure of farm economy has no effect on the calcultion of farm income. No great mistakes seem to result in the calculation of the intermediate products if we consider the farm income to be g.

Taking into consideration the fact what the Ministry of Agriculture and Forestry calls the farm income is the difference beteween the total income and total expenditure and that the calculation by the term of business is the characteristic of the book-keeping, we cannot but say that there will be errors in the calculation of the farm income as the result of economic activities for a certain period of time, unless we take into account the increase and decrease in the intermediate products.

In order to grasp the intermediate products the following method seems feasible. Needless to say that the value of increase or decrease in the intermediate products is equal to that obtained by subtracting the value at the end of the business year from that at the beginning of the year. It is difficult, however to calculate the price because they do not enter the circulation process, and because the prices will not be the same at the beginning and end of each business period. For these reasons, it is more practical to subtract those intermediate products at the beginning of the year which are equal in use value from those at the end of the year, and to estimate the value of the remainder at the current price prevalent at the end of the year ; this will be the surplus for the productive means intended for self-supplies, that is the intermediate products.

This method looks similar to that adopted and made use of by the Ministry of Agriculture and Forestry from 1942 to 1947 in its farm household economy survey. In those investigations, however, the value of the intermediate products at the beginning and end of the business year was calculated by the current price then existing, therefore, the increment value obtained by subtracting the value at the beginning of the year from that at the end of the year would not necessarily represent the quantitative increase of the intermediate products, if there were fluctuations in money value during that period. For an example, let us take a case where there is 1,000 "*kan*" of manure and 800 "*kan*" of Manure respectively at the beginning and end of a business year. If the base of calculation is changed, that is, the price of manure is changed from 5 yen per "*kan*" at the beginning of the year to 7 yen per "*kan*" at the year end, 600 yen obtained from substracting 5,000 yen from 5,600 yen, will the increment price of manure for that period ; but there is a decrease of 200 "*kan*" in the use value which, in

turn, will affect the production for the following year. The method mentioned above aims to prevent the calculation of increase or decrease in the intermediate products from being affected by the price fluctuations. Although the book-keeping aims at the calculation of price, not the volume of the use-value, it is only proper that it should find the appropriateness of its calculation of the difference by the year end price through the comparison of the quantities of the goods on spot, in the sense that the intermediate products do not enter the circulation process. The characteristics of this method is to be found in the fact that the increase or decrease in the capital which belong to the commodity economy and the variations in the form of capital can be recorded and calculated by the double entry system and that, to supplement it, the value calculation is performed on the phase of actual good economy.

3. A few words should be said on the relation of the actual goods economy to the calculation of productive cost in connection with the understanding the part played in book-keeping of the actual goods economy in the agricultural economy. The defficulty of grasping the self-supplied goods of the farm economy by the prices together with the perception and the method of treatment of the three items, farming side-business and household business which are to be discussed in next section, make it still difficult to calculate the cost of production which is an objective calculation. It is a question how to evaluate the actual goods and the wage for self-supplied labor, and a question of allotment of expenditure to each department. It is necessary to make fictitious evaluation in these two phases in making calculations in book-keeping and in the cost of production. According to Prof. Kimura, "In a farm book-keeping, it is necessary to grasp the farm economy as a living form for the reproduction of life, and to calculate the cost of producing rice in the light of the conrcete fact that rice is not product of a simple productive form".(12) He continues his argument, "All the expenses incurred in the farm economy should be grasped at the point of outgoing. It is necessary to make distinction between the expenses for farm management and those for household economy. When it is difficult to make distinctions, every expense paid in cash, including those far marriage and funeral services, should be put under the cost of production for farm economy. The production cost per "*tan*" or "*koku*" is obtained by dividing the cost of production of the farm products by the quantity of product".(13) His view represents the idea that every cash payment including living expenses should be included in the cost or reproduction. Unless the value used in the production of self-supplied elements, W_β is equal to the value produced W_b, the exclusion of the self-supplied elements from the book-keeping calculation will not be proper as the calculation of the total capital invested in the farm management. It may be said that his idea is not proper even if the self-supplied elements come partically into calculation

when the expenses for household economy is regarded as the cost of production in the farm management.

In calculating the cost of production, including those for self-supplied elements we must resort to a fictitious calculation in which every expense spent in production should be evaluated and distributed, regardless of enternal or external transactions, because the method considered above is not available. The result thus obtained will be a calculation inclusive of a large number of selfish elements. Here lies great trouble in the calculation of the cost of elements, but in calculating the cost of production, the expenses incurred on the intermediate products should be evaluated for each product by the market price and distribute the expense over the department which consumes it.

V. Evaluation of Self-Supplied Labor

1. Let us now go back to the problem left out of our discussion in connection with the book-keeping of the self-supplied economy in the farm management, that of the self-supplied labor and the family expense. This is the problem of evaluating labor for the purpose of book-keeping. It is basically connected with the essential of the small farm economy and the most important factor in the self-supplied economy from the standpoint of the farm book-keeping.

Let us first consider the characteristic idea—family expense=self-supplied labor income, in connection with the understanding of the self-supplied labor. This idea is based on the premise that the family expense is the cost of reproducing self-supplied labor, that the household business and farming business cannot be distinguished from each other in a small farm management and that the small farm management exists in fact in a combined form of household work and farming work.

The agricultural accounting can be divided into two large classes from the viewpoint of its objective. One is that it is possible to make calculations for the farm management proper, side work and household work. It maintains that the farm management can be separated from the farm economy and the double entry system can be applied to calculate the profit. If such is the case, the departmental calculations can easily be done.

Prof. Otsuki represnets this school, and his theory has been adopted by the Ministry of Agriculture and Forestry, and other agricultural societies in their economic investigations and accounting informations. What he advocates in his book "Agricultural accounting" is the Kyoto University system of agricultural accounting, making records and calculations by dividing the farm economy into income economy and household economy. He says, "As a matter of fact, the farmer thinks of his own economy as consisting of income economy and household economy, though in complete as it is. For an example, he thinks that he has

earned so much income (or gain) for a given year, of which he has spent so much for a given year, of which he has spent so much for household expense, in consequence of which he has made so much surplus or loss in his agricultural economy, and the decrease in his income is due to the cultivation of different crops or to the increase in the expenses for education of his children. Therefore, in the agricultural accounting, the farm economy should be devided into two phases of economy, namely, income economy and household economy. The system of accounting devised under such consideration is the agricultural accounting of income economy".(14) Such a contention is made not only by Prof. Otsuki but also by the accounting system in general. In short, the idea behind this contention is to divide the farm economy into phases of productive economy and consumptive household economy, and seek profit of the farm economy by calculating the income from the former and subtracting from it the total expenditure for household business. The concrete method of calculation is as follows: "First calculate the agricultural income which is the fruit of income economy, and the household expenditure which is the fruit of the household economy, and then calculate the surplus of the agricultural economy as aggregate calculation". (Referred to Table 5) Here the income economy as assumed to be an enterprise and the circulation of capital is assumed to be in progress to produce the surplus value.

In order to follow this veiw more closely, let us see the view maintained by Prof. Kondo that the separation by such a method is improper and that it is necessary to consider the small farm economy as consisting of single economie units, that is, of unified whole, in contrast to the general view prevalent in the past. According to his "Science of Agricultural Accounting".

(1) The expenditure to be borne by the farm economy .... is the living expenditure for the year.

(2) In the farm economy, many items under the household expenditure come in the form of the self-supplies, and the food expenditure in the household expenditure is tautamount to the self-supplied feed. The reverse is the use of the human manure, which is the left-over from the household economy, in the farming department.

From 1 and 2 mentioned above, the household expenditure may be considered to be the cost of reproducing the labor power in a management.

(3) Throughout the household, side and farming business, there are assets common to all af them. This is the natural with them. The labor of the family members, regular farm hands, houses and work animals come under them.

(4) Public taxes, no matter how they may be imposed, are to be considered as burdens on the total income, and there is no significance in dividing them among the household expendition and agricultural expenditure as farming expenditure.

(5) It is not only impossible but also meaningless to allot a loan among farming, side and household work.

In view of the above, it is necessary to consider the farm economy as a unified whole, as a body made up of independent departments."[15]

If we see these views closey, we shall find that (1) and (2) differ from (3), (4) and (5). (3), (4) and (5) have their origins in the actual state of the farm economy, but they rather state the difficulty of making allotment of taxes, expenditures and loans among the household, side and farming business. On the other hand, (1) and (2) from a base on which rests the idea that the farm economy should be considered fundamentally as a unified whole. In other words the household expenditure should be regarded as the cost of reproducing the labor power in a management. In accounting, this is to make the household expenditure the wages for the self-supplied labor, and this is what makes the accounting system by Prof. Kondo different from other system.

2. Let us see what characteristics the concrete accounting system of Prof. Kondo has in comparison with that of Prof. Otsuki. From the view point of accounting system, both are double entry. Otsuki system, however, is an applied form of double entry, because (1) it turns all the transactions into cash and make single entry under cash, though it maintains the character of double entry when transactions are viewed in the light of actual state, and because (2) it can distinguish between the system of calculation based on properties and that based on capital by the itemized classification of cash transactions, though it maintains the dynamic and static calculations due to external single entry for cash transactions. They work as slef-checking for the results obtained by the above system of accounting.[16] On the contrary, Kondo's system has adopted the farm of double entry and made it a perfect means of analysing the agricultural economy. He bases his contention on "When we consider the fact that it is because the double entry is built on the fundamental premises, simplied and mechanized and perfected that the double entry is so complicated, we cannot but think it will be easier for the farmer to see the principles of double entry system than to do complicated calculations under compromised form of single entry system".[17] He also explains his system by quoting from Laur. "The essence of the double entry is to be found in that it can make departmental calculations".[18] By Otsuki's system, all the transactions should be turned into cash which, for the beginner, seem easy to understand, but it will be complicated in the case of barter and transactions on credit. Moreover, it will be nescesary to do some sort of technical manupilations in the case of departmental calculations. In this respect, Kond's system is simple and easy if we have some knowledge of accounting, and it will not be necessary to do any special calculation in the case of a departmental calculations.

Contrary to the Kyoto University system of accounting which makes records and calculation on the premise that the farming business can be distinguished from the household business, Prof. Kondo does not make calculations separately for the farming and household business, but aims at making calculations for the farm management as a unified whole. He says, however, that to make calculations for the farming and family business simultaneously does not mean to confuse the one with the other ; it means that the calculations are made simultaneously, keeping the destinction between the two.

If it is possible to keep account for two departments kept separately, will it not be in contradiction with the reasons given for the view that the farm economy should be considered as a unified whole ? What he means to say is probably that the distinction should be made when it is possible to do so, but when it is difficult to do it, no distinction would be made. His fundamental idea, however, is to be found in his interpretation that the family expense is the cost of reproducing self-supplied labor.

As regards the evaluation the self-supplied labor the Kyoto University system by Prof. Otsuki does not require such an evaluation, because he thinks the agricultural income, includes the reward for the self-supplied labor, and the surplus of the farm economy can be calculated by subtracting the family expense from the above amount. In short, he recognizes the peculiarity of the farm economy, and calculate the income of the farm management as a whole. Such income, the agricultural income, includes the reward for the self-supplied labor as well as rent on the land owned by himself and the interest on the capital invested.

Although the Kyoto University system does not normally calculate the wage for the self-supplied labor, such wages will be calculated by multiplying the average wage given to common labor in that district by the number of days, the self-supplied labor furnished by the family members, when agricultural business is fictitiously made an enterprise on the same footing as other trades and industries. What is calculated as the increment in the capital account by Prof. Kondo corresponds to the agricultural economy surplus of the Kyoto University system, but it differs from the latter in that it does not seek the agricultural income in the course of process of the calculation.

In order to simplify the problem let us discuss the examples of entry in the book given at the end of Prof. Kondo's "Science of Agricultural Accounting". If we are to find the comprehensive result, namely, the agricultural economy surplus, it is not improper to include the amount of money spent as the family expenses in the item which properly belongs to other expenses. For example, it is clearly observable that the family expenses are not all included in the collective loss and profit account given the examples of the book, but in the

accounts for the interest on the loans, public taxes and impositions, repairs and depreciation funds ; as they are all in the debt side of the loss and profit account, they may be considered to have no influence on the credit calculated as the result of the whole agricultural economy, or the amount in the capital account, though there may be some variations either in the increase or decrease between their mutual accounts.

In this instance he does such a strange operation as not to include in the household expenditure what clearly seem to be the household expenses. This can be seen in the separation made by including the account for furniture in the depreciation funds. It may be said that his method is proper only in the sense that the result for the unified whole will be the same as in the case of confusion of the household expenditure.

Let us now consider his method from the viewpoint of the rate of profit which is thought to be a kind of index for the economic activity of an enterprise. Needless to say, the rate of profit is the rate of surplus value of the whole capital invested, which is represented by the formula $M/C+V$. $C+V$ is the value paid out by the capitalist for the production of commodity, which to him is the sum expended on the commodity. In looking over the collective profit and loss account mentioned above in this instance, we find profit, but not the expenditure required by the economic activity for the formation of such a profit. The rate of profit calculated here is tantamount to $M/C+V'+$family expenditure when V' is variable capital connected with employed labor. If the family expenditure is thought to be the wage for the self-supplied labor, the addition of V' to the family expenditure would be V, which, in turn, express the rate of profit by making the equation $M/C+V$. This is one of the effects brought about on accounting by the evaluation of the family expenditure.

Interpreting the family expenditure to be the cost of reproducing the labor required for the farm management, and assuming the equation of the family expenditure = the wage for the self supplied labor, it will be possible, in accounting, to evaluate the wage for the self-supplied labor, and it will be unnecessary to subtract from the expenditure of the farm management the family expentidure, with it is difficult to separate from the former and which is calculated by fictitious evaluation. There remains, however, another important question.

Reversely, it may be natural that he should have made the family expenditure the wage for the self-supplied labor. Among the reasons mentioned above why the agricultural economy should be grasped as the unified whole of the agricultural business and family business, he said in (3), (4) and (5) that there is a considerable number of item which it is difficult to make distinctions between the agricultural and family business. In other words, if we are to admit the establishment of items which cannot be distinguished, the expenditure in such

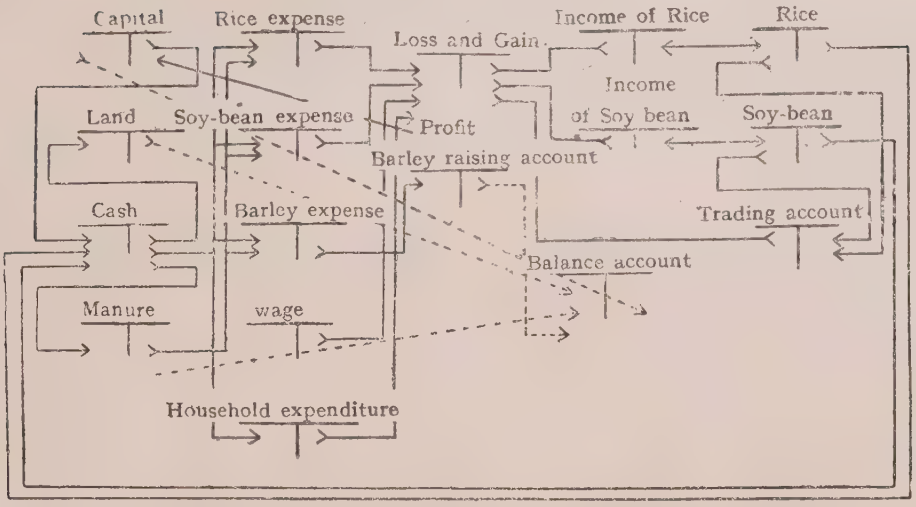
accounting would be a part of C+V'+the family expenditure. In such a calculation the whole family expenditure would be in the calculation rather than by means of imperfect calculations as mentioned above.

3. When it is necessary to make calculation of the cost of production and those of other department in the production in order to make judgement on the management not only by the comprehensive results of the management but also by the comparison of the departments in a farm economy, it will be a complicated matter how to evaluate the self-supplied labor used in the management. The benefit of the double entry system is to be found in that it can calculate the comprehensive results of the farm economy simultaneously with those of each department in that economy.

It is because the depatrmental calculations are parts of the comprehensive calculation that we shall be able to discuss and criticize the results of the calculation and make them useful for other purposes. For these reasons it is necessary to consider the evaluation of the self-supplied labor in connection with the departmental calculations.

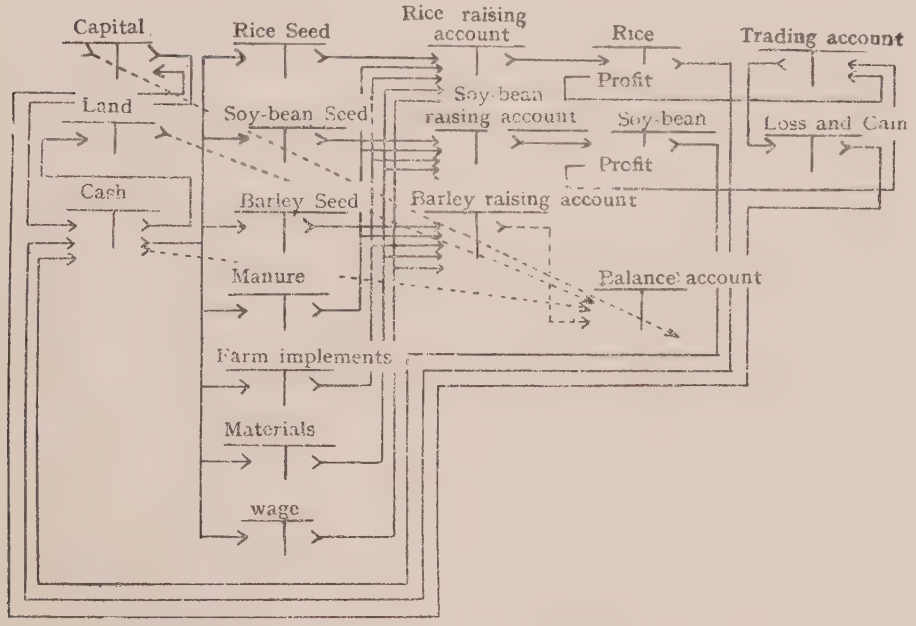
Although the wages for the regular employees and also for the temporary employees and the wages for the industrial workers have been considered as the base for evaluating the self-supplied labor, Prof. Kondo and Kimura consider the family expenditure. Kndo's method has many difficulties because his method of calculating the family expenditure is imperfect in that it does not include the whole family expenses. Consequently, even if the family expenditure is distributed over each department according to the number of work hours as the cost of reproducing the self-supplied labor, it will be necessary, in calculating the result of each department to make detailed calculations, even when it is obliged to make a wider calculations for the family expenditure. For example, the depreciation funds, when considered to come under the family expenditure, should be entered in the book so as to be calculated as such. As Kondo's mentioned, when there is a considerable number of items which cannot be classified under the agricultural, side and family business such as taxes and loans they should be alloted by the base determined by considering the mutual relations existing among the three business mentioned above. The same may be said of the calculations for each department; expenses spent in each department should be alloted accurately to that department. As it entails many troubles and requires fictitious evaluations to allot these expenses to each department, it may be well to calculate excluding those which are difficult of allotment as long as the purpose is to grasp the outline, if not the accurate, the result of each department. This method is made use of in the commercial accounting.

Although the funds such as buildings should be calculated according to the classification into household and agricultural business, it is proper, because of



* The self-supplied and barter economy in the farm management is omitted.

Fig. 1. System of accounts according to Prof. Kondô.



* The self-supplied and barter economy in the farm management is omitted.

Fig. 2. System of account when raising account is established.

the difficulty of such a classification, "to adopt the ficitious method, according to the calculation of the household expenditure of estimating the total rent by handling the income from such buildings as a whole, and the product obtained by multiplying it by the rate of using the buildings as the rent paid from the household economy to the income economy and borne by the household economy".(19)

Next, let us see how the relations of one account with another is kept by alloting the household expenditure to the wages for the self-supplied labor. It is impossible to make departmental calculations including the calculation for the cost of production until the settlement time, although the calculation for the cost of production is itself the calculation of the result. Thus, we must make the household expenditure the cost of reproducing the labor power for the management, to make the total for the year and to allot to each department the result calculated on the basis of such as the number of work days. The wage for the self-supplied labor will be calculated only when such a method is followed.

In following such a method as this, it will be impossible to establish such an account item as manufacturing account found in the industrial accounting, because the wages for the self-supplied labor and the number of work days done by the family members cannot be calculated until the time of settlement. The reason why Prof. Kondo is not establish such an account as rice raising account in order to grasp the capital in the intermediate production, is to be found here. In other words, it shows how difficult it is to include the departmental calculations in accounting. (Refer to Fig. 1, Fig. 2)

Although the income from the sale of the unpolished rice depends upon the properly estimated price, it may be reasonable to disregard the grasping of the cost in the process of production from the viewpoint that the law of value does not work properly in the farm management whose porducts differ from those of industrial management. But the question is more fundamental than this, that is, whether it is proper or not to regard the household expenditure which is the cost of reproducing the self-supplied labor as the wage for the self-supplied labor. Generally speakng, the wage is the value of labor, namely, the value of the necessaries of life of the laborer. As the value is the amount of labor socially required, there is a doubt economically to apply the expenses for necessaries of life spent in irregular individual life. Therefore in calculating the wages for the self-supplied labor as an element in the production when the cost of production is calculated, it is proper to adopt as the base the wages for temporary employees and others which are accepted as such socially. Which standard should be adopted depends upon the purpose for which the calculation for the cost of production is to be done.

In accounting, however, it is sometimes handy to make the household ex-

penditure the wages for the self-supplied labor. From the view point of the farm management, the payment of the wages for the self-supplied labor is the income for the expense of the family ; they are cancelled in the course of calculation. Even under the double entry system, a proper balance can be kept ; and it will be possible to calculate the surplus of the agricultural economy designated by the Kyoto University system.

On the contrary, it is not proper to estimate the wages for the self-supplied labor on some other base and to put them in the calculation us expenses, because it will break down the balance between accounts under the double entry system. In such an instance, some counter account should be made to counter balance them, that is when the self-supplied labor is furnished to the management, it must be itemized ; debt — the wages for the self-supplied labor and credit — profit. This is based on the idea that fictitiously the self-supplied labor is furnished from the household department to the management department, which is expended in the production. When this self-supplied labor is used in rice cultivation, it will appears as follows : debt — rice raising account, credit — the wages for the self-supplied labor.

Although it seems improper, in accounting, to include in calculations what is supplied free of charge, such calculations as mentioned above are reasonable from the standpoint that the management department is independent of others in the agricultural economy. This method originate in the idea that the agricultural economy consists of the management department and household department and that the element of self-supplied labor cannot be disregarded in it. If we wish to make calculations for accounting simultaneously with the departmental calculations, there will be no other way except the one mentioned above and in doing the departmental calculations we must itemize the cost of labor power and profit under the department which require them.

As another method it is possible to allot in the last stage the estimated amount for the self-supplied labor to the departments which omitted the wages for the self-supplied labor, without itemizing such accounts in the intermediate process, that is, without doing any estimation for the wages for the self-supplied labor in the intermediate calculation for accounting. The longs and shorts of this method have been given in connection with the discussion of Kondo's idea.

A few words should be said in connection with the departmental calculations. If it is necessary to do the departmental calculations, the scope of calculation should be widened to the transactions between the departments. If the calculation of the result of the department is the object, it will be necessary to grasp qualitatively the transactions between the departments, however fictitious they may be. To what scope and to what degree we should do this depends upon the purpose for which such calculations will be made.

VI. Conclusion

We have compared the agricultural capital and individual industrial capitals in order to understand the fictitious character of the former as well as the peculiarity of its circulation. We have considered how the principles of the accounting should be applied to agricultural management in order to grasp the agricultural capital in circulation.

The principle of accounting should be applied as follows ; the system of double entry and its fundamental characteristics must be utilized, because they will give complete means to analyse the agricultural management.

From the view point of calculating exactly the results of the management, it is impossible to exclude the self-supplied elements because it is necessary to draw our attention to the intermediate products and the self-supplied labor in recording and calculating the results. As regards the intermediate products, emphasis should be laid on the substantial side-view of the capital from the standpoint of economics. It has been proved that it is proper to evaluate the capital essentially on the current price.

As regards the self-supplied labor we have said that it is the question of how we take the household and agricultural business in a farm management. According to Prof. Kondo, the agricultural economy is a unified whole not a collection of departments independent of one another from the viewpoint that the household expenditure is the cost of reproducing the self-supplied labor ; his method of accounting is proper only in seeking the surplus of the farm economy, but clearly improper in seeking the agricultural income. And it is impossible to know the household expenditure which is to be calculated as the wages for the self-supplied labor until the time of settlement. It has a defect that the calculation of the cost of production and other departmental calculations cannot be done at the same time. Moreover, it is questionable economically to assume fictitiously that the household expenditure is the wage for the self-supplied labor.

Except for special cases, the agricultural accounting must distinguish, even though fictitiously, between the agricultural business and household business and when the departmental calculations are to be made, the evaluation of the wages for the self-supplied labor should be made on the standard generally accepted in the society.

In summary, it may be said that in order to apply the modern double entry system to the small agricultural economy, we must make fictitious evaluations because the elements of natural economy cannot be disregarded. In the past Otsuki's system and Kondo's system of agricultural accounting have been representative of the accounting in Japan. Their defects in the accounting forms reflect the existence of feudalistic elements in our agricultural organization. In

spite of it, we must make the application of the principles of modern accounting; how to introduce and evaluate the elements of natural economy in accounting is not only the question of techinique, but also is the question which cannot be settled unless the small farm economy is grasped economically and theoretically. The present writing is a trial study on the agricultural accounting from such a point of view.

Summary

Agriculture in Japan is still carried out chiefly with labor of the family hands, and no remarkable progress seems to have been made toward the capitalistic form of production, leaving behind many elements of natural economy. In order to analyse such an agricultural management economically and theoretically, the knowledge of modern accounting must be utilized. In such an analysis, we must take into consideration the field in the category of natural economy as well as the field of exchange eeonomy in the sense that it is what maintains agricultural management economically and keeps production on the run. In other words, it is necessary to make fictitious evaluation of self-supplied labor and goods. It is here that the difficulty of agricultural accounting lies.

In the present paper, the author, in order to solve rationally such a difficulty, tried to explain the fictitious character of the capital in agriculture in contrast to the capital in industry and how the principles of commercial accounting should be applied in order to grasp the special character of the capital in agriculture in the course of circulation in which moves. The results of the present study may be summarized as follows:

1. The form of circulation in which the capital in agricultural management of small-scale farming in Japan which has many elements of natural economy may be expressed

$$\begin{array}{ccccccccc} G & - & W_\alpha & \cdots\cdots & P & \cdots\cdots & W_a' & - & G' \\ & & \| & \cdots & & \cdots & \| & & \\ & & W_\beta & \cdots & & \cdots & W_b & & \end{array}$$

in which the characteristics are to be found in the attachment of W_β and W_b to the circulation $G - W \ldots . P \ldots . W' - G'$ of the capital in individual industry. Consequently it is necessary that W_β and W_b should be woven into the modern accounting. W_β represents the intermediate products and family labor power, and W_b the self-supplied goods and home-consumed goods.

2. In order to grasp the general result from small-scale farming with book-keeping, it is necessary to add the product, obtained by multiplying the quantitative difference of each product by the market price, to the profit obtained

through exchange economy, because of the intermediate economic character.

3. In order to grasp the result of each branch of small-scale farming, each self-supplied goods should be evaluated by the market price, and it should be distributed to each branch every time it is consumed.

4. To count family labor as an expense for management it should be described as the wages paid to self-supplied laborer. As Prof. Kondo pointed out, such a method of evaluation as to count home expense as wage for self-supplied labor in book-keeping, because in agriculture in Japan labor of family hands is put to farm product in large quantity, is not correct in finding out balance of agriculture or in calculating accounts for each section, though it is convenient in finding out balance of household economy. This method of evaluation makes it impossible to grasp the economic activity until the end of the year and is irrational from the point of the theoretical economics.

5. In the case of calculation of the result of the farm management as well as of each branch of the management, wage of family labor should be evaluated on the social standerd such as the standard wage paid to temporary or regular employees of the country in which the farm is located, or wages paid to industrial workers in the city. So in books, it should be journalized

Dr.	Cr.
Wage for self-supplied labor	Profit and Loss

When applied to rice product, it will be as follows:

Dr.	Cr.
Account in rice product	Wage for self-supplied labor

Literature Cited

(1) K. Marx, Das Kapital (translated into Japanese by F. Hasebe), 1st Ed., Tokyo (1950) 1548.
(2) K. Yoshida, Bull. of Inst. for Agri. Research, Tohoku Univ., **2** (1950), 285.
(3) K. Marx, ibid., 496.
(4) M. Sweezy, The Theory of Capitalist Development (translated into Japanese by K. Nakamura), Tokyo (1951) 88.
(5) K. Marx, ibid., 3rd Ed., 1780.
(6) M. Otsuki, Farm Book-Keeping, Osaka (1949), Preface.
(7) T. Nakanishi, Studies on the managing cost, Tokyo (1936) 27.

(8) Y. Kondo, Science of Agricultural Accounting, Tokyo (1950) 80.
(9) W. Kimura, Studies on the Cost-Accounting, 2nd Ed., Tokyo (1944) 240.
(10) Statistics and Research Division, Ministry of Agriculture and Forestry, Report of Farm-Household Economy Survey in 1944, 1945, 1946, Tokyo (1950) 5.
(11) Statistics and Research Division, Ministry of Agriculture and Forestry, Report of Farm-Household Economy Survey in 1948, Tokyo (1950) 3.
(12) W. Kimura, ibid, 245.
(13) W. Kimura, ibid, 245.
(14) M. Otsuki, ibid, 17.
(15) Y. Kondo, ibid, 66.
(16) Y. Kashiwa, Studies on the Agricultural Economy, **14** (1928), 100.
(17) Y. Kondo, ibid, Preface 2.
(18) Y. Kondo, ibid, 2.
(19) M. Otsuki, ibid, 39.

東北大學研究所報告
(農　学)
第3卷

昭和27年3月25日 印刷
昭和27年3月30日 発行

編集者　寿時富彌
仙台市片平丁75金属材料研究所内
東北大学研究所連合会
発行者　木村次郎
東北大学農学研究所
仙台市片平丁41番地
印刷者　笹気幸助
印刷所　笹気出版印刷株式会社
仙台市堤通27 電話2027, 2207番

Printed by
SASAKI PRINTING & PUBLISHING Co., Ltd.
27, Tsutsumi-dôri, Sendai, Japan.

CONTENTS